ENGINEERING

An Illustrated Weekly Journal

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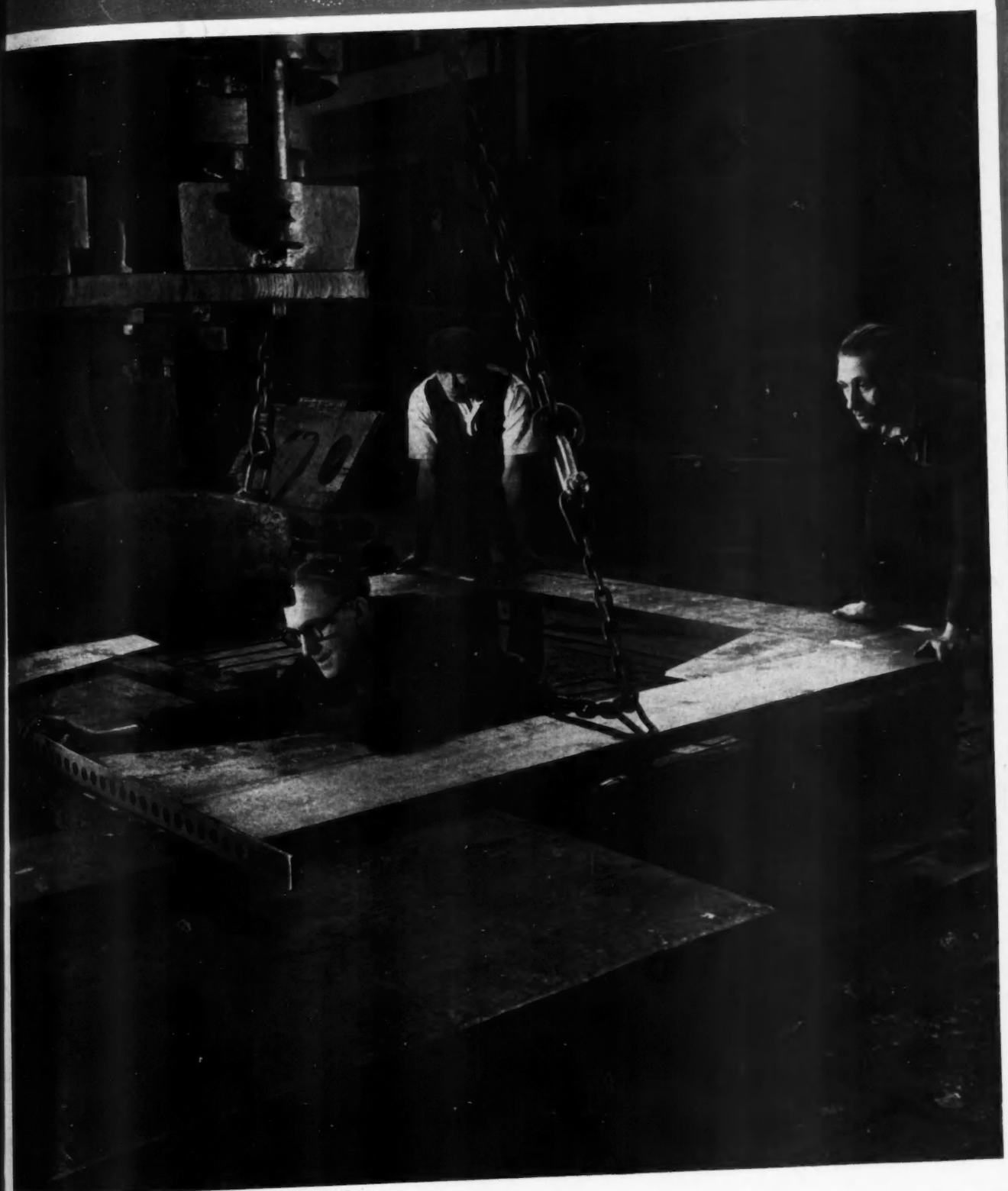

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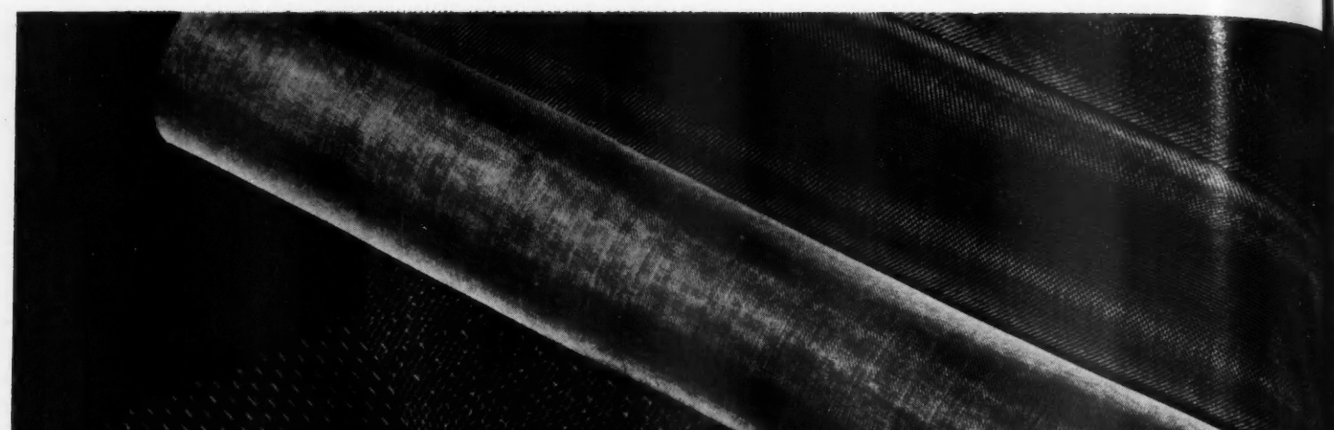

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An Illustrated Weekly Journal

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THE MORE WE ARE TOGETHER

THERE has been since the war a considerable growth in the number and size of manufacturing groups, particularly in the engineering industry. The change is continuing and may radically alter the structure of the industry within the next few decades.

To a considerable extent the trend is due to the nature of technical developments—only a large organisation can afford to use highly expensive equipment for specialist purposes or to establish departments for advanced work. In that respect the industrial group is inevitable and beneficial. It pioneers in fields where the small or medium firm is quite unable to venture, though it raises new problems, such as the difficulty of effective communication and the need to find a way in which the employees do not get that cog-in-a-machine feeling.

The more obvious results have been an increase in company size and a broadening of the range of products handled by top management—often through a holding company. The success many of these groups have achieved in the past ten years has shown that management's task in the handling of widely different products is far from insuperable. On the contrary, it would seem that in most cases the quality of management has improved; partly because bigger men have been attracted to do a bigger job, partly because the problem of management is more obvious and cannot be allowed to drift. Management methods vary widely but they are positive methods nevertheless, and new techniques are being evolved. There is increased financial strength, and a readiness to call for specialist advice.

But the greatest gain is probably in imagination, and in a more accurate perception of what is a growing industry and what is a shrinking one. The managements tend to survey the world rather than a 50 mile radius around the factory. New products are introduced, and whether this is achieved through the addition of a company, or the acquisition of a licence to manufacture, or through the efforts of a development team, the result tends to be a revitalising of the whole enterprise. Instead of the company suffering from hardening of the arteries as its basic products become less and less appropriate for further development, it is rejuvenated by the new additions to the family of products. The pioneering spirit in one part of it is often sufficiently strong to permeate the whole group and to affect its thinking, thereby influencing the handling and development of traditional products. These dynamic consequences of grouping may prove to be the most positive gain of British engineering, and the most effective method of adaptation to the revolutionary changes brought about by recent technical advances.

Perhaps the most important of all contributory factors to the growth of manufacturing groups is the tax motive—working both ways. High taxation on earnings and the freedom from tax (so far) of capital gains makes investment into companies which offer scope for development, whether because of bad management or lack of capital, very worth while. High death duties break up the private company structure. The credit squeeze and the shortage of working capital are forcing companies, particularly the small and medium size, into the arms of more powerful units who are attracted by any skills available; for some time it has been much easier to buy a company in order to get buildings, labour and plant than to get approval for, recruit or purchase these items. This attraction applies even more strongly to companies who have good teams of engineers with valuable experience. The last major direct reason for the growth of groups is the attraction of those companies which have "hidden" or "written-down" assets that can be translated into working capital. Investment trusts have in recent years bought company after company simply using the first mortgage to finance their next deal.

Added to these factors—all important though not all yielding a good influence—there are others; some non-recurring such as the accumulation of cash by companies in the coal, gas, electricity, transport and steel industries on nationalisation; some gaining in importance, such as the desire to avoid total dependence on one product, like motor cars, or aircraft, or on a monopoly buyer like the National Coal Board or the Central Electricity Authority.

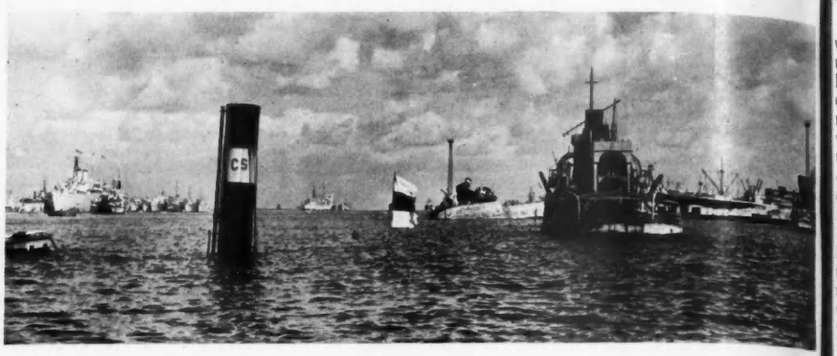
Left till last, because it is the most healthy, is the desire to break in where a long-term expansion can be foreseen and where, generally, numbers of enthusiasts have set up their own small show to develop their own designs and are found lacking capital or management skill. Because of the inertia which is inevitable with a large group, there will always be scope for founding a small business to develop an idea. The most go-ahead groups foster new ideas, but they tend to work on a different plane to that on which a small firm works. The research and development laboratories behind a multiple organisation have exceptional facilities, but the projects on which they focus their attention are usually of a different character than those to which the small man devotes his energies. Both extremes of business organisation have their part to play. The little man may be handicapped but he is not daunted. He can squeeze in where the giant is too big.

Plain Words

The recent focus on water supply organisation by the Minister of Housing and Local Government, Mr. Duncan Sandys, questions the utility of the small water supplier—the modern equivalent of the parish pump. Of the 900 water undertakings in England and Wales, some of which the Minister hopes to re-group, the 400 which supply populations less than 10,000 are collectively dwarfed by the massive Metropolitan Water Board. At the other end of the scale, 84 serve populations in excess of 100,000. The householder might well ask whether the proposed re-grouping is wise. Will it lead to a cheaper or a better water supply? Smallness in size inevitably inhibits specialisation. Efficiency is extremely difficult to achieve.

Of the 750 units serving populations of less than 30,000, one eighth are managed by chartered civil engineers; about half those between 30 and 100,000 are so served. During the past decade some amalgamations have taken place, reducing the number of water units by 100, but it is the compact band of water companies which have displayed the greatest progress in a friendly dog-eat-dog activity. To-day one fifth of the companies serve populations of over 100,000, compared with one twelfth of the local authority undertakings, whose slower combination has been confined to the formation of those *ad hoc*, largely successful, but unpopular outsiders of local government, the water boards. The smaller units which almost wholly pattern the rural areas are facing a raw financial wind, despite monetary succour from the Treasury for rural water. Compared with cities, where one mile of main will feed a 1,000 population, the rural districts may require 6 to 10 times this length.

Economically the case for some re-grouping appears proved, but it leaves a real hurdle in the psychological opposition from those who may rightly claim that the parish pump is their heritage, with a long and noble history originating in some cases in the very first of Britain's nationalised projects—the water supplies of Roman Britain. In the last analysis there is no material problem, only a problem of human relations.



Sunken vessels at Port Said. The bucket dredger is the "Peleuse"; behind is the canal salvage vessel "Pollux" with her stern damaged by explosives. The funnel is of the hopper "Neptune."

CLEARING THE SUEZ CANAL

URGENT SALVAGE BY ANGLO-FRENCH FORCES

It looks as though the biggest engineering problem at Suez will not be the removal of the 50 or so sunken vessels in the harbour and the canal itself, but the re-conditioning or replacement of the canal equipment, particularly the tugs and dredgers, and the re-establishment of the fairway.

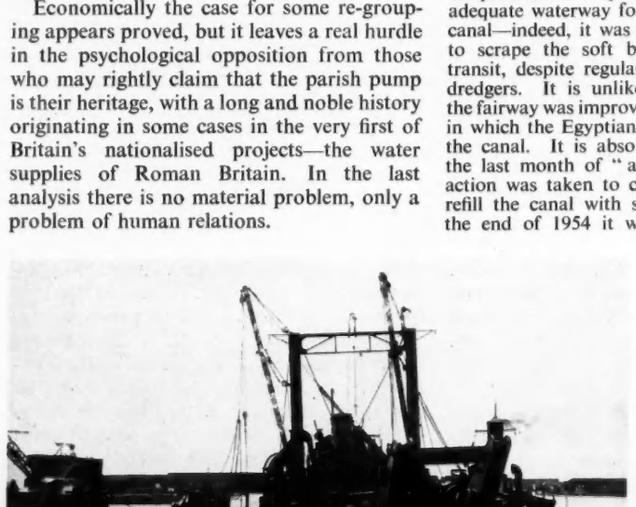
The tugs and dredgers that were employed on the canal were all specially made vessels, well suited for the unique conditions under which they were operated—heavy duty in restricted areas but under fair-weather conditions. Exactly similar ships are not used elsewhere. It is unlikely that what suitable craft do exist could be spared from their present tasks to form even temporary replacements at Suez. The period of adapting or building the craft required, if Colonel Nasser's men not only sunk but also destroyed the Canal Company's vessels, will be far longer than the three to nine months that have been predicted for raising the scuttled vessels or removing the other known obstructions. And with any great lapse of time a very serious problem will have arisen due to the sand that will have been deposited in the canal. Continuous dredging was of paramount importance in maintaining an adequate waterway for the vessels that used the canal—indeed, it was not unusual for the largest to scrape the soft bottom somewhere during transit, despite regular work by the company's dredgers. It is unlikely that the condition of the fairway was improved during the three months in which the Egyptians "owned" and operated the canal. It is absolutely certain that during the last month of "armed conflict" negligible action was taken to counter nature's efforts to refill the canal with sand. Between 1950 and the end of 1954 it was necessary to excavate 53 million cubic yards of material to meet the needs of shipping requiring passage. Six months lapse will generate a pretty problem of balancing the deployment of improvised dredging equipment against the need to give the first ships room to pass.

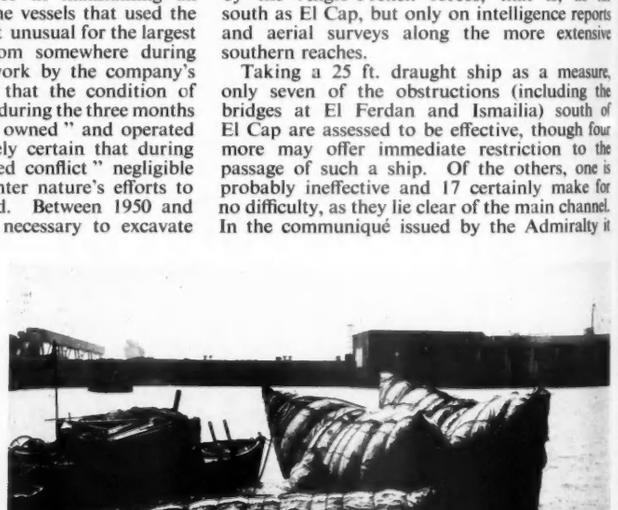
The Egyptian Government may or may not own the canal, but it is quite certain that they have neither the money nor the equipment to put it in good order again. They have damaged the canal—even if not irrevocably—but it is only Western Europe, and in particular the United Kingdom, which has the capacity and urgent desire to return it to its former good order.

OBSTRUCTIONS

The first full report of the obstructions caused by the Egyptians reached London last week-end and the location and nature of the blockages are shown on the map on page 643. With 20 wrecks in the harbour at Port Said, the total number of obstructions—including two blown bridges—was then put at 50. This figure is based on a full survey within the area occupied by the Anglo-French forces, that is, as far south as El Cap, but only on intelligence reports and aerial surveys along the more extensive southern reaches.

Taking a 25 ft. draught ship as a measure, only seven of the obstructions (including the bridges at El Ferdan and Ismailia) south of El Cap are assessed to be effective, though four more may offer immediate restriction to the passage of such a ship. Of the others, one is probably ineffective and 17 certainly make for no difficulty, as they lie clear of the main channel. In the communiqué issued by the Admiralty it





Salvage vessels and "air-bag" equipment used during and after the last war have been re-mobilised by the British Admiralty and were among the first units sent to Port Said when the British and French Governments took action in Egypt.

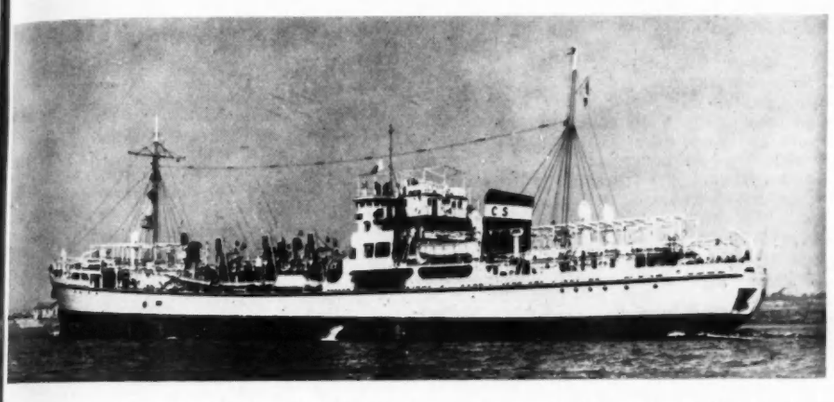
was observed that other obstructions as yet undiscovered may be present below the surface. During the boat survey of the Allied-held portion of the canal, the fairway was wire-swept to a maximum depth of 30 ft. and a width of 300 ft. without finding anything that was not visible on the surface. (The channel has a depth of 30 ft. or more over a width of about 220 ft., the full depth of 46 ft. in the northern reaches being maintained only for a width of 118 ft.)

The obstruction is not so severe as it might have been. Apart from the vessels belonging to the canal, no craft of any size was available to the Egyptians. There are, however, 12 foreign vessels trapped in the canal and at least some pressure has been brought (apparently so far unsuccessfully) on their crews to abandon them. Should they be surrendered to the Egyptians they too may be scuttled in order to delay clearing operations further. None of these vessels is British, though two are tankers on charter to British companies: the Italian Amalfi, of 10,387 tons and Panamanian Brigette, of 9,243 tons, which would be the largest vessels forming obstructions if they are eventually sunk.

At Port Tewfik, in the south, the two vessels sunk in the channels are the salvage vessel Castor and probably a River Class frigate; a third, a salvage tug, has been scuttled adjacent to the harbour jetty, and a fourth, a small ship, has been placed across the entrance to Port Ibrahim, a small fishing harbour outside the original canal concession. Along the main stretches of the canal the most serious obstructions are likely to be the suction dredger Louis Perier and the two bridges at El Firdan and Ismailia. As the latter was only a pontoon structure it should not present much difficulty. The bridge at El Firdan, on the other hand, may prove a more troublesome proposition, for it was a long-span structure completed only three or so years ago to give easier navigation than the old swing bridge built during the war. It will be remembered that a vessel fouled the piers of this bridge last year, causing a serious impediment to shipping for a short while.

At Port Said the wrecks are more extensive, although even here only seven or eight appear to be in the main channel or in Ismail basin. By far the largest—and most accurately placed for causing an obstruction—is the suction dredger Paul Solente, the subject of one of the illustrations to this article. She is reported to have eight holes in her hull and, by the week-end, the task of patching her was well advanced. The other wrecks are comprised of smaller bucket dredgers, a small floating dock, hoppers and tugs, the largest being the Hercule which, though old, is one of the biggest owned by the canal, with a deadweight of just over 600 tons. She is lying in the fairway, but well to one side and facing well into the stream.

Originally, at least three floating cranes—including the 150 ton hammer head—had been sunk across the inner entrance from the outer basin by the Central Mole. But reports over the week-end showed that the two smaller cranes—of 15 tons and 80 tons lift—had already been shifted clear of the channel by the British forces. If they can quickly be put into working order they will prove invaluable in clearing the rest of the harbour.



The suction dredger "Paul Solente" which has been sunk across the fairway in Port Said harbour. Eight holes in her hull have been patched by British forces prior to raising.

CLEARANCE WORK

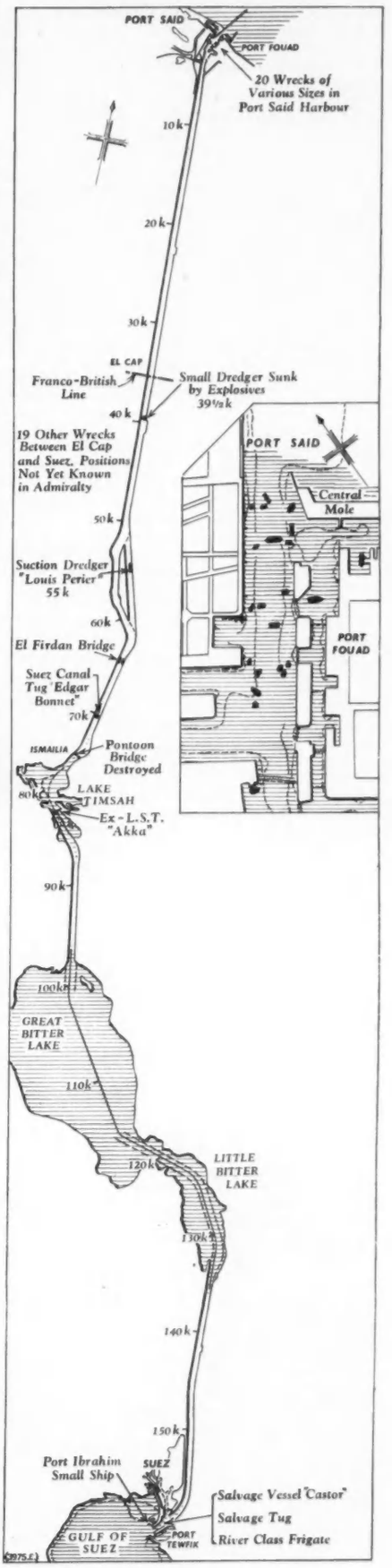
Although political issues and points of international law have still to be settled on who owns and who is to operate the canal when it is cleared, it is the British, along with their allies, who have the necessary equipment ready in the quantities required to do the task in a reasonable time. The United Nations have sent in special observers, with their policing force, to make an assessment of the damage done to the canal and its installations, but to get the work done quickly they will have to accept the offer of salvage resources by the United Kingdom Government.

The organisation assembled at Port Said by the Royal Navy by the middle of last week (some salvage vehicles were included among the first Allied forces sent to Port Suez when the present emergency arose) comprised two ocean salvage vessels, one coastal salvage vessel, one wreck-dispersal vessel, one boom-defence vessel, one 1,200 ton dumb lifting craft, four salvage pontoons and a tug, together with personnel, stores and equipment. Foremost among this equipment will have been air compressors, undersea cutting and welding heads, and diving gear, together with the other paraphanalia required for salvage operations, for which the United Kingdom possesses the unrivalled experience gained during the war when clearing and retrieving vessels sunk during air raids or by mines along the coast line; to say nothing of the added experience obtained immediately after the war in clearing the ports, canals and riverways of Western Europe.

RE-MOBILISED SALVAGE FLEET

For the work at that time, the British Admiralty built up a large and effective organisation. This force has now been dispersed for several years, some on normal peacetime charter to British companies, others to ghost reserves where they have been "cocooned." The fleet has now been re-mobilised and, indeed, by the time we go to press, some units will already have reached Port Said. This additional force comprises two ocean salvage vessels, eight coastal salvage vessels, one wreck-dispersal vessel, six lifting craft, one salvage craft, eleven boom-defence vessels, six salvage pontoons and an unspecified number of tugs. These ships and equipment will have been gathered from many parts of the world and several units will approach from the south, directly into Port Tewfik.

The amount of work required to shift each wreck will depend on two factors: the type of



Locations of ships sunk by the Egyptians in the Suez Canal and its harbours.

vessel and the damage done. Small merchantmen and tugs which were simply scuttled will be sealed and the water pumped out until buoyancy is regained. The problem in these cases is to ensure that the ships come up on a more or less even keel, avoiding for certain the worst calamity of the vessel turning turtle during the lift. To some extent the work will be simplified by the easy water, the regular depth of the operation and the fact that the bottom, though soft, is not sticky and should give up the wrecks without developing any considerable suction. But visibility under water is poor.

Where the craft have been holed, the first job will be one of patching. Here the recent improvement in under-water welding will greatly facilitate the work and it may be possible, if the necessary apparatus can be got out there, to make use of under-water television, though this would seem to be a refinement, for normal diving surveys should be quite adequate at the depths concerned. More extensive use may also be made of "air bags" for obtaining additional buoyancy; these can be particularly valuable for blowing the water out of open compartments without the need for full patching and sealing, though reasonable precautions (such as blanketing) are desirable to prevent the bags being punctured by torn steelwork.

Where the ships have been sunk by the use of heavy charges so that parts of the hull have been blown away, more substantial expedients may have to be adopted. The damaged portions may be cut away and lifted out on the horns of a salvage vessel or by using the refloated cranes. The remainder of the hull will then have to be patched sufficiently to enable it to be pumped out and the buoyancy recreated so that it can be towed away. The block ships which have been filled with concrete offer another problem. On the one hand the Egyptian concrete is probably so bad that it can be broken out—not, admittedly, an easy job under water, but a useful way of lightening the vessel further as she begins to rise—but, before that, it will be necessary to put slings attached to salvage barges under the hull, which is then lifted by towing the barges apart. Alternatively, it has been suggested that these concrete-filled ships might be blasted into handleable pieces which could then be removed by single salvage vessels.

COMPANY EXPERIENCE

The Canal Company has considerable experience of clearing the canal. In the past, "deblocking" has been a fairly frequent task. In the war an elaborate organisation was built up for handling ships immobilised in the fairway. Early in 1941 a number of mines were dropped into the canal and four vessels were wrecked in such a position as to reduce the navigating channel seriously. A particular example was the old Greek vessel, the Aghios Georgios, which was cut in half by a mine; in this case two of the canal's tugs, Atlas and Hercule, succeeded in dragging the pieces clear of the channel. What could be done then, can be repeated. Other vessels sunk then and cleared away included two hoppers and a lighter, similar in many respects to those that are now obstructing the canal. And, last year, as has already been mentioned, the company's staff successfully cleared the canal when a big merchantman struck the new bridge at El Firdan.

During 1955, north-bound goods traffic passing through the Suez Canal weighed nearly 87,500,000 tons, of which about 75 per cent. (66,900,000 tons) consisted of oil and its by-products. The south-bound traffic amounted to just over 20 million tons. The significance of the blocking of the canal is discussed in Weekly Survey notes; the canal should, in the terms of the original charter, be able to offer free passage to ships of all nationalities. The growth of traffic through the canal during the last 10 years is a clear indication of the importance of the canal to international commercial relationships to-day. The quicker the canal is returned to a condition of economic operation, the better for everyone.

Letters to the Editor

THE COST OF VARIETY

SIR, I was delighted to read the article on "The Cost of Variety," on page 584 of your issue of November 9 last. It gave much-needed publicity to one of industry's most crippling diseases: a malady the more dangerous because the sufferer seldom realises his trouble. This disease—unnecessary variety—can affect all parts of the organism; but, as you point out, its results may be worst when the design office is affected.

It is remarkable how frequently new drawings are made when similar or identical ones already exist, and how often new components are manufactured on specially prepared jigs or fixtures when already existing tooling would serve the purpose, or when components already made would be suitable. The difficulty is that firms do not know the resources they possess, and all too often possess no means of finding out.

Yet the problem of finding out is simple enough, as your article makes clear: what is needed is up-to-date information. The simplification of design, the co-ordination of design policy, and the reduction of excessive variety in this field, as in all others, depend on the use of foolproof means of access to information. This, in turn, cannot be achieved without that orderly classification and coding which will enable the designer to find, at the drop of a hat, every drawing that might be suited to his purpose before deciding to undertake new work. Laziness is built into all of us, and, therefore, once installed, the use of such a method is assured; for the designer will quickly see how much work it can take off his shoulders, and how much more easily he can find an existing drawing than make a new one.

I have frequently seen cases where several identical parts were regarded as different from one another simply because they belonged to different machines. In every instance, the design of all but the original parts was unnecessary—and yet inevitable in the absence of a way of discovering that these originals already existed.

The savings from correctly planned and systematically carried out variety reduction come from the drawings firms don't make, the parts they don't buy, and the jigs and fixtures they don't prepare—because they already possess what they need. Their problem is often no more than to reveal their own resources. Believe me, they would surprise themselves if they really set about doing it.

Yours faithfully,
EDWARD G. BRISCH.

26 Victoria-street,
London, S.W.1.
November 16, 1956.

★ ★ ★

SHEAR DEFLECTION IN BEAMS

SIR, May I reply to Mr. Dunne's letter published in your issue of November 2, page 549, criticising my article on the shear deflection in beams?

I agree that the use of shear strain energy should give a more reliable value for λ than Timoshenko's method, using the maximum shear strain. However, for most engineering sections, the results obtained by the two methods differ by only a few per cent., while the calculation by the maximum shear-strain method is very much simpler.

Mr. Dunne's second criticism appears to me to be quite trivial. In determining the shear strain in the beam we are surely entitled to resolve the stresses on the cross-section into orthogonal components, consisting of direct and shear stresses, as in the theory of elasticity. Mr. Dunne's version of equation (11) would in fact be obtained if we consider the shear force acting on a new cross-section perpendicular to the neutral line, rather than on the original cross-section. Since the angle ψ_2 is extremely small (being comparable with the shear strain in the beam material) the numerical results obtained from the two assumptions are practically indistinguishable. For example, if we consider an extreme case of a rectangular-section bar, loaded in tension to a stress of 30,000 lb. per sq. in. (a figure approaching the yield point of mild steel) it is found that the only effect of Mr. Dunne's proposal is to modify certain of the coefficients in equations (12) to (14) by about 0·3 per cent.

I consider it preferable to work in terms of the deflection components y_1 and y_2 rather than the total deflection $y = y_1 + y_2$, partly because the additional manipulation required to express the equations in terms of y introduces mathematical restrictions on their validity. Thus, equations (12) to (14) of my paper are valid over any length of the beam which has no externally applied concentrated force or moment. On the other hand, Mr. Dunne's equation for y contains a term $\frac{d^2 p(x)}{dx}$ on the right-hand side, and is therefore restricted to lengths of the beam where both $p(x)$ and $\frac{d p(x)}{dx}$ are continuous. It will be noted also that Mr. Dunne's end-conditions are cumbersome compared with those given in my article (published October 5, page 428).

Yours faithfully,
R. P. N. JONES.

Post Graduate Department of Applied Mechanics,
The University,
Sheffield.
November 12, 1956.

★ ★ ★

"VISCO-STATIC" OIL

SIR, Under the heading "Anti-Friction Additives" on page 286 of your issue of August 31, you refer in the third paragraph to a "visco-static" oil. Visco-static is the trade mark of the British Petroleum Company, registered (No. 748282) in respect of lubricating oils and greases. It has been widely used by this company to distinguish its own B.P. Energol brand of multi-grade oil and we are concerned to maintain its distinctive character.

Yours faithfully,
for the British Petroleum Co., Ltd.,
H. E. PERKINS.
Patents, Licensing and Trade Marks Branch.

The British Petroleum Company, Limited,
Britannic House,
Finsbury-circus,
London, E.C.2.
November 13, 1956.

★ ★ ★

TERCENTENARY OF THE PENDULUM CLOCK

The Netherlands Ambassador is to open an exhibition at the Science Museum, South Kensington, on Tuesday, December 4, to commemorate the three-hundredth anniversary of the invention of the pendulum clock by Christiaan Huygens. The exhibition, which has been organised by the Science Museum and the Antiquarian Horological Society, will illustrate Huygen's invention and show how it turned the earlier erratic timekeepers into a precision instrument. Examples of the earliest pendulum clocks, made on the Continent and in this country, will be shown and a working model to illustrate vaious scientific features of the pendulum will be included among many other interesting exhibits. The exhibition will be open to the public from December 5, 1956, until February 24, 1957.

Weekly Survey

Cover Picture: *After a part has been fabricated, it is often stress relieved and then checked for distortion before being passed for the next operation, which is machining. In the illustration, such a check is being made on a heavy mild steel frame.*

* * *

Impact of Oil Shortage

At first sight it might appear that the shortage of Diesel oil and fuel oil which is likely to develop over the next few weeks, despite a sudden and inexplicable optimism about oil supplies among the public in the last week or so, may be exceedingly widespread. The big users of the lower distillates are the iron and steel industry, commercial transport, glass, electricity and gas. The British Iron and Steel Federation announced last week that a prospective shortage of oil from the Middle East might cut steel production below its recent record levels. This is the direct impact.

An assessment of the effect of a large shortage over a number of months is exceedingly difficult to make. Thus, in the case of gas, the maintenance of pressure can be much more important for certain industries than the recording of a small reduction in the supply of oil to gas works might suggest. There is a complicating seasonal factor, too, in that stand-by plant at gas works will probably be required within the winter months to deal with peak loads and will not therefore be available to fill in the gap left by a fall in marginal supplies of oil until the spring of 1957. The prospect of a continuing shortage of oil raises again such problems for British Railways as the advisability of going over to Diesel locomotives instead of complete electrification. Here, too, of course, the issue is not as simple as it sounds. A greater degree of electrification by the railways would increase the demand for electric power, which will be increasingly dependent for its marginal supplies of oil until atomic energy takes over on a large scale.

The possibility of reducing the amount of catalytic cracking at the refineries, thereby reducing the amount of petrol in order to maintain the supply of oil for industry, still seems to be one of the most likely ways of reducing the impact of the shortage on factories and industrial services, but there is a notable silence on the subject from the oil companies as yet. There is an eloquent reluctance on the part of all concerned to suggest that the petrol user, which means largely the private motorist in this case, will be asked to bear the main burden of the coming oil shortage or that the burden will be a major one. There is much to be said for facing the problem now and preparing the public for it rather than run the risk of delaying the rationing of the private motorist at the expense of industry.

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Cost of the Suez Expedition

If the viewpoint on the Suez intervention is limited to the fiscal consequences in the current budgetary year, the bill is not very heavy. In fact, the Government were able to say in the debate on the subject last week that the budgetary position was not greatly affected at all. It seems probable that the expedition will have cost somewhere between £35 million and £50 million in additional military expenditure.

Besides the comparatively modest size of the expenditure involved, the Government spokesmen threw out two particular observations about the impact of the Suez affair on the national economy. The Chancellor of the Exchequer pointed out that sterling had very substantial reinforcements which could be brought up if the conventional gold reserves are put under too severe a strain. One of these is, of course, the International Monetary Fund, but foreign speculators would not be unduly impressed with a call on reserves from such a source as that. Mr. Reginald Maudling, the Minister of Supply, said that this extra Government outlay would not upset the disinflationary balance of the last budget because of the present level of savings. What those savings may amount to at the moment is anybody's guess. Official estimates of savings are a residual item in the statistics of the national income at the best of times, and present estimates of the trend of savings must be crude in the extreme. Nevertheless, it will be a major point in favour of economic stability if the Egyptian excursion can be absorbed without adding to inflationary pressure, thanks to the general abstinence from spending by the public as a whole.

Viewed from an economic standpoint rather than a fiscal one, the picture is less reassuring. The most serious part still remains that a vital raw material for industry, namely oil, will be acutely short and that industrial production may start to run down. If this should happen, and if it should not be accompanied by a reduction in wages (and such a reduction is most unlikely to occur), the inflationary effect of the Suez crisis could be much more severe and protracted than is likely to be foreseen from the limited viewpoint of the fiscal position. The danger is that the Suez situation might create something approaching a condition of siege for this island if oil becomes acutely scarce.

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The British in India

The British contribution to India's second five-year plan is beginning to take solid shape. First, the Indian Steelworks Construction Company—ISCON—the consortium of leading steelworks contractors and engineers, signed on the last day of October a contract to build an integrated tiron and steel plant at Durgapur in West Bengal. Second, Babcock and Wilcox, together with Vickers, announce the formation of a new company with Associated Cement Companies of Bombay, to be known as A.C.C.-Vickers-Babcock (Private) Limited (A.V.B.). The new company are to put up a heavy engineering works in the vicinity of the projected steelworks. Third is the publication last week of Imperial Chemical Industries's project report to the Government of India on setting up a dyestuffs industry. Fourth is the announcement by A.E.I. Limited that they have submitted to the Indian Ministry of Production a report on the establishment of a heavy electrical plant factory.

All these schemes—only the first has been approved so far—involve the expenditure of very large sums. In the case of the steelworks this amounts to over £62 million f.o.b. for imported plant, equipment and materials, in addition to which over £15·5 million will be spent on items of plant obtained in India and on civil engineering work. The heavy engineering plant, which is to produce cement-making machinery, mining machinery, large pumps, heavy gears, steam-generating plant, pressure vessels, cranes and mechanical-handling equipment, will cost £8 million initially and will take three years to build. I.C.I.'s scheme for a single dyestuffs factory—extending over 200 acres—will cost about £22 million.

There is now little doubt that the World Bank will play a leading part in financing such schemes, despite the rather chilly effect produced by Mr. Eugene Black's warning that the Bank did not like India's planning and the limited opportunities it offered to private industry. Transport facilities require urgent development and the Bank are prepared to treat railway and road schemes as "top priority;" likewise they are prepared to finance electric-power projects. A more critical deficiency than the lack of capital is the lack of skilled labour. I.C.I.'s report underlined the shortage of trained personnel as one of the main factors operating against the development of a dyestuffs industry. In the case of the steelworks also there is a shortage of technicians, but in this case the British Government have undertaken to train all necessary men under the Colombo plan. The education and training of Indian engineers, much of which will have to be done in the factories of those companies who provide the plant, is a *sine qua non* of her industrial advancement. It is also a unique opportunity for British industry to win supporters in the great struggle already developing between Britain, Germany, the U.S., and the U.S.S.R. for the Indian capital goods market.

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Rolls-Royce Aero-Engine Orders

The delay in bringing the Britannia airliner into service and the decision of B.O.A.C. to buy 15 Boeing 707 jet aircraft have raised doubts as to the future of the British aircraft industry. These developments, however, relate to only a small part of the total market and doubts as to the future are contradicted by the present rapid progress of the industry in export markets. It was announced in the House of Commons at the end of October that it is expected that total exports of aircraft, aero engines and parts and equipment will amount to about £105 million in 1956, an increase of 64 per cent. over the corresponding figure for the previous year. In the first eight months of 1956, exports of complete aircraft were valued at £51½ million and of engines at £18½ million.

The prospect of a further expansion in aero-engine exports is confirmed by the announcement last week that Rolls-Royce have firm orders for 2,500 gas-turbine aero-engines for civil use amounting to over half the world's orders for such engines. The bulk of these orders (about 2,000 units) consists of the Dart turbo-propeller engine which powers the Viscount and the Fokker Friendship, and is also to be used in another British machine—Aviation Traders' Accountant airliner. In addition, however, some 100 Conway by-pass turbo-jet engines have been ordered and a similar number of Avon engines. The former is to be used for the Douglas DC8 and the Boeing 707 and the latter for the Comet jet airliner for B.O.A.C. and Capital Airlines in the United States. Over 80 Tyne turbo-propeller engines have been ordered. This engine is to be used in the Vickers Vanguard and may also be adopted as an alternative power plant for the Lockheed Electra. There seems to be little doubt that substantial further orders will be received for these newer engines and when the demand for replacements and spares is taken into account there would appear to be every prospect of a continuation of exports at a high level.

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Smithfield and Agricultural Machinery

Agricultural machinery will occupy two-thirds of the exhibition space at the Smithfield and Agricultural Machinery Show which is due to open at Earls Court on December 3. It is hoped that this display of the latest developments in farm mechanisation will help to reinforce the improvement in total sales which has taken place since August of this year. During the early part of the year, output of both agricultural machinery and tractors was well below the corresponding figures for 1955.

In the case of tractors this trend has continued, but output of agricultural machinery in August and September, 1956, was higher than in the previous year. According to the monthly statistics issued by the Agricultural Engineers Association, Limited, home sales of both tractors and agricultural machinery in September, 1956, were higher than in the previous year, and the Association consider that there is not likely

to be any further deterioration in the home market for the remainder of the year. To some extent home sales were probably assisted by the exceptionally difficult harvest conditions. It is, however, the trend of exports which is likely to exert the greatest influence on future production, since export sales have been estimated to account for about 70 per cent. of output. In the first eight months of 1956, exports of all types of agricultural machinery excluding tractors showed a small rise to £10·3 million, compared with £10 million in the previous year.

The future outlook for exports of both agricultural machinery and tractors is considered encouraging in view of improving trade with South Africa, Canada and South America. But the main threat to British exports, particularly in the case of tractors, is the growing strength of German competition. The Agricultural Engineers' Association say that sufficient comprehensive figures are not available to decide the extent to which German manufacturers are increasing their share of total world exports, but from such evidence as is available they consider that the German share of world trade increased appreciably during 1956.

British manufacturers are hoping for a substantial increase in exports to China, where it is reported that the Government have decided that western style tractors are more suitable for the farm mechanisation programme than the heavier Soviet models. Massey-Harris-Ferguson shipped a test order of 100 Ferguson tractors to China during September and their sales team have estimated that China will require some 1·4 million tractors over the next ten years.

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End of an Export Era

Last week saw the publication of the October external trade figures and of a new trade agreement with Australia. The first marks the end of free transit through the Suez canal before it was blocked in the present emergency. The second is the replacement of a trade agreement signed between Britain and Australia as long ago as 1932. The era has gone and we shall not look upon its like again. It is unlikely that the Suez canal will play quite the same role in this country's trade as it has done in the past, and important changes are also on the way in this country's largest export market.

The record export figures achieved in October doubtless owe something to the rather poor performance in August and September. If allowance is made for changes in the price level, the rate of increase last month in the volume of exports was about 5 per cent., which is approximately in line with the long-term rate of increase over the last year or two. Imports are now increasing too, but this is to be expected for industry had been running down its stocks during 1955. The blocking of the canal may begin to have an effect on the trade returns in November.

The new trade pact with Australia is to operate for an initial period of five years. Its main provision is to increase the export of Australian wheat to this country. In addition, the Australian Government have asked this country to take note of their wish to have greater freedom in reducing preference for British goods in Australia. The purpose of this is to help reduce costs in Australian industry and to increase Australia's bargaining power with countries outside the Commonwealth. Thus the writing is on the wall; this country can expect increasing competition in the Australian market both from domestic manufacturers and from other countries. The Australian Government have agreed to give continued tariff preference to United Kingdom goods now in receipt of it, subject to the right to reduce those preferences to the new guaranteed minimum margins of 7½ per cent. for capital goods and 10 per cent. for most others. Australia does not intend to make early reductions in existing margins except where there is no domestic Australian production.

Reactions to this new agreement are bound to be mixed. In the short run the principle of preferential treatment for British goods is preserved, while the ability of the Australian economy to earn sterling exchange and therefore to remain a buoyant market for imports is increased by the wheat agreement. In the long run, however, the Australian market is a certain target for increased penetration by other industrialised countries.

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Honourable Subsidy

In these days when the detection of export subsidies of one kind and another in foreign countries is such a popular activity in British industry, it is well to keep abreast of the more subtle varieties which have developed or may come into existence. An interesting proposal has been put before the Ministry of Trade in Japan by the Japan Machinery Export Association. This Association suggests that the Government should insure machinery manufacturers from losses arising from changes in raw material prices.

The problem is well known. Customers are increasingly reluctant to accept "escalator" clauses in contracts dealing with increases in the price of raw materials. They are anxious to return to the pre-war days when a price quoted by a supplier was firm till the date of payment. In Japan, where the rate of industrial recovery is being accelerated to a dangerous extent, the possibilities of inflation affecting both home-produced and imported raw materials are formidable. It is possible under such circumstances for, say, the Japanese engineering industry to be faced with steep and sudden increases in steel prices. The scheme is not one to recommend itself to commercial underwriters. Hence the Association's request that the Japanese Government should give it their serious consideration.

The advantages to Japanese manufacturers of heavy engineering equipment (to take a case where a long gestation period is common for contracts) are clear enough. The manufacturer can quote on fixed raw material costs in the knowledge that the difference between estimated and actual costs is covered by a Government insurance policy. He need worry little about a margin for contingencies in his tender. Such a plan would therefore almost certainly give the Japanese a price advantage in tendering for export orders. Furthermore—and this possibility will certainly not have been lost on those who have thought of the scheme—the proposal could be a very useful thin end of a very unpleasant wedge for the British engineering industry.

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Cheerful Epilogue ?

The Suez crisis and the prospects it brings of oil shortage and petrol rationing were too late to affect the cheerful optimism of most companies' annual reports published last week. The chairman of Tube Investments, Limited, Sir Ivan A. R. Stedeford, reported an increase of £22 million in turnover and of about £2 million in trading profits. The group have considerably expanded into steelmaking in order to strengthen further "the point at which T.I. has been especially vulnerable over a long succession of steel-hungry years."

In addition to the Round Oak Steel Works purchased three years ago, the group have now acquired two others—Park Gate Iron and Steel Company and Renishaw Iron Company—and half the share capital of a fourth, the Byfield Ironstone Company. In all, they have invested just over £12 million and secured capacity for about 750,000 ingot tons a year. Sir Ivan's report ranges widely over manufacturing industry and trade. Total exports of the group expanded by 5 per cent. despite a contraction in cycle sales in some markets. A new tube company in India, Tube Products of India Limited, is expected to commence production next spring. Cycle production is being concentrated at Handsworth, Birmingham, "in what we believe will be the most modern integrated bicycle factory in the world." New products are being launched—in domestic appliances and switchgear—and a new technological centre has been opened where the group's long-range scientific research will be installed. Sir Ivan looks forward to increasing competition and considers the Restrictive Trade Practices Act as one of the most considerable and promising pieces of industrial legislation in recent times, but warns that the dangers of the proposed free trade area in Western Europe are as real as the prizes, and which persist despite the warm political glow now suddenly shed on the scheme. He concludes that testing and difficult times are evidently ahead and that "British industry needs long years of heavy capital investment if it is to surmount the capital struggle now begun."

This is echoed in many other reports. Peter Brotherhood Limited report an expenditure of nearly £½ million on capital equipment in three years, and say they are now well equipped to deal competitively with "any work which may reasonably be entrusted to us." Cochran and Company, Annan, Limited, consider they can face the future with confidence as, "while costs may rise still more we shall benefit from the new machines—many of them labour saving—which we have installed in the works during recent years."

Increased competition for a rising demand for engineering products is the expectation of all these companies, and higher capital investment the main solution they advocate.

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Company Accounts

The annual reports and accounts of Folland Aircraft Limited, and Thos. W. Ward Limited set a high standard in the presentation of financial results to shareholders. Folland were awarded the Accountant prize for the best presented accounts, and Thos. W. Ward were winners in 1954. Both go out of their way to give a full and frank statement of their results and a detailed analysis of their prospects. They publish explanatory statements of balance sheets which detail the nature of assets and liabilities and—in the case of Folland—explain the full meaning of each item heading. For example, "General Reserve—to ensure continuity of employment and to allow for future contingencies, e.g., increased replacement costs of machinery, etc." Explanatory statements are also given in respect of profit and loss accounts, showing the year's total income from sales, services and investments and how it is made up. The amounts spent on purchases of materials, wages and salaries, administration, and those allocated to depreciation, taxation, reserves and dividends are all shown separately. The hopes expressed by Mr. C. L. Hill, chairman of Folland, that the accounts would be "more informative to those who are without accounting experience," were well founded.

Folland's Gnat lightweight fighter is a great success story, though Mr. Hill warns that "there are certain rather unusual risks attaching to any contracts for a machine which is not entirely out of the development stage." His statement is unusually frank and has a most confident ring. The volume of orders on hand has risen from just over £300,000 in September, 1947, to nearly £5 million by June 30 this year. Turnover for the financial year was £2·9 million, £350,000 more than in 1954-55. Employment fell slightly, to 2,660, and Mr. Hill commented on the difficulty "of holding together a labour force in the present-day position of rather smallish orders for large aircraft structures which are ever increasing in complexity." He added that his Board were greatly worried at the tendency of highly trained personnel to emigrate, particularly to North America, which is being experienced throughout the British aircraft industry.

DEEP DIVING IN THE ROYAL NAVY

H.M.S. "RECLAIM'S" INSTALLATIONS

H.M.S. Reclaim, from which a new world flexible-suit diving record of 600 ft. has recently been established by Senior Commissioned Boatswain George Wookey, one of the ship's two diving officers, is the ship on which all the deep divers of the Royal Navy have been trained, and in which the main experimental work on diving to depths below 180 ft. has been carried out. She is one of the two British ships equipped for diving on oxy-helium mixtures, the other being H.M.S. Kingfisher, whose primary function is that of submarine rescue.

Unlike Kingfisher, which started her life as the ocean salvage vessel King Salvor and was converted for deep diving and submarine rescue some two years ago, H.M.S. Reclaim, commissioned in 1948, was specifically designed for the purpose. Within three months of commissioning, one of her diving team, Petty Officer William Bollard, diving to 535 ft., set up a world record which has been held by Great Britain ever since.

H.M.S. Reclaim has a displacement of 1,820 tons, is 217 ft. long and 38 ft. wide. She carries a complement of seven officers and 89 ratings, of which about 15 are divers. Her propulsion machinery comprises a 750 h.p. triple-expansion steam engine supplied by two forced-draught oil-fired marine boilers. She has a bunker capacity of 283 tons of fuel oil, 30 tons of Diesel oil, 40 tons of feed water and 80 tons of fresh water. The electrical generating supplies consist of a 120 kW turbo-generator, a 60 kW reciprocating, steam-driven generator, and two 60 kW Diesel driven generators. Her refrigerating plant capacity is adequate for about four months' supply of food and dairy produce.

ROUTINE DIVES TO 450 FT.

During the eight years that Reclaim has been in service, the diving team has continued to build up experience in deep diving, and to-day dives to 450 ft. depth are carried out as normal routine. At this depth the Royal Navy divers are able to work for up to 20 minutes; beyond this period the time required for decompression becomes prohibitive, for, as with the nitrogen present in compressed air, helium under pressure enters into solution in the diver's tissues and gives rise to "bends," or compressed-air illness, if the diver ascends too quickly. To overcome this, the practice is to ascend from a dive in a series of steps, stopping at predetermined pressures for a length of time dependent on the maximum depth of the dive and the the time spent at this depth. One of the Reclaim divers' tasks has been to establish, in conjunction with the Royal Naval Physiological Laboratory, decompression tables for guidance during oxy-helium diving.

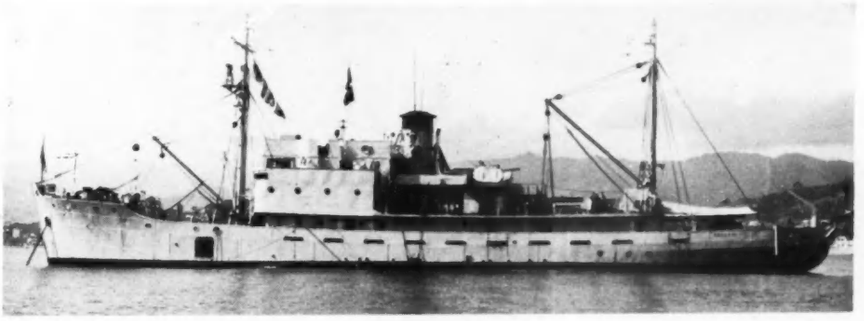
Wearing deep-diving injector-type diving dress designed to minimise carbon dioxide concentration in the helmet, dives to a depth of 300 ft. are usually carried out on compressed air. At 300 ft., the partial pressure of the oxygen in the air has risen to 2 atmospheres, and at pressures higher than this oxygen is toxic to most people. At this depth, too, the narcotic effects of nitrogen—which like the effects of strong drink, afflict different men in different degrees—are sufficient to reduce the efficiency even of the most highly-trained and carefully selected divers. Using instead a mixture of oxygen and helium, these two disadvantages can be overcome; the percentage of oxygen in the mixture is limited to a safe value, and up to the present no narcotic effects have been experienced with helium. The mixture, however, does not provide enough oxygen until a certain depth has been reached, and it is therefore the practice in the Royal Navy to start the dive on air and to change over to oxy-helium mixture at a specified depth. All the Royal Navy's helium has to be imported from the United States and the cost, therefore, of an oxy-helium dive is quite appreciable, depending on the depth, duration, and work done.

In Reclaim, the diving flat from which all diving operations are controlled extends across the width of the ship, about midships, and at each side are diving doors operated by hydraulic rams, from which the divers enter the sea which lies about 4 ft. below the door sill. Adjacent to each door are the main control panels for the air and oxy-helium supplies. Also housed in the diving flat is a three-compartment recompression chamber for exercise and for treating divers affected by bends—as well as for the routine decompression of divers and their attendants, as explained later. The Navy's decompression chambers are now completely fireproofed and free from all electrical wiring, being lighted from outside through a roof port; some years ago this was not the practice, and a fire resulting from a burst lamp bulb in a recompression chamber caused several fatal casualties.

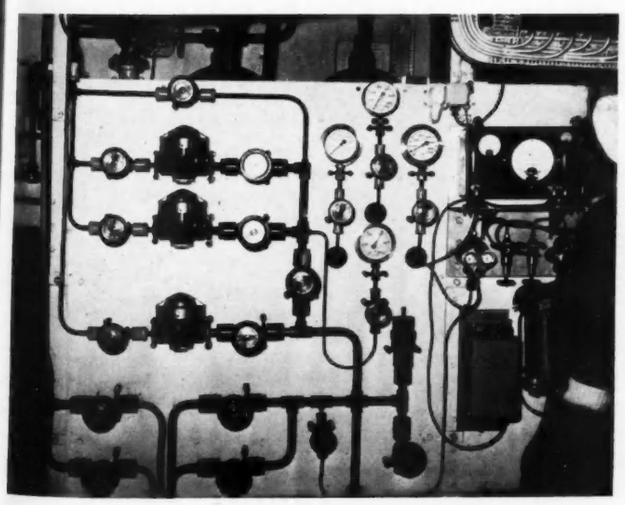
SUBMERSIBLE DECOMPRESSION CHAMBERS

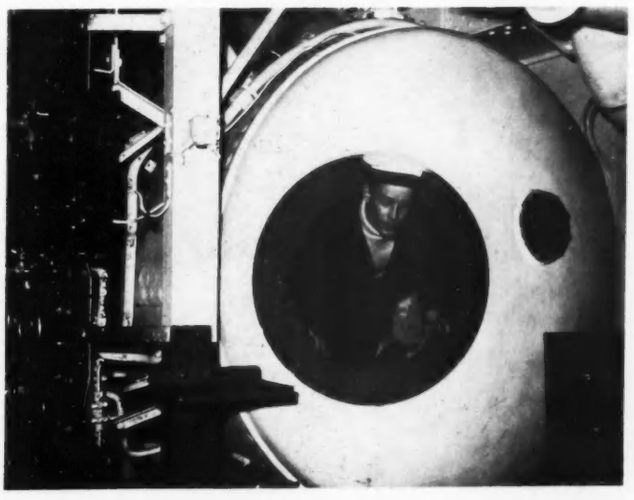
Opposite the recompression chamber is a control panel for the submersible decompression chambers (S.D.C.) which are used to collect the diver on his way to the surface. These chambers, which can be fed with compressed air from the ship's supply, have doors at each end, and can either be sealed off to form a watertight pressure chamber, or can be used as a diving bell with the lower door open. The two S.D.C.'s are stowed in holds on the deck and are handled by a derrick and electrically-driven 3 ton winch. The 2½ in. non-rotating wire cable is checked for strength every 12 months at the Royal Naval dockyard.

Responsibility for the diver's welfare is in the hands of the diving officer and his staff, the diver's attendants, the control panel operators,



H.M.S. "Reclaim," from which Senior Commissioned Boatswain George Wookey recently broke the world flexible-dress diving record, is one of the Royal Navy's two deep-diving ships fitted for oxy-helium diving.





In the left hand illustration is shown the oxy-helium control panel, and on the right, the three-compartment recompression chamber in which divers and their attendants can complete their lengthy decompression stages in comfort and warmth, and in which divers afflicted with bends are treated.

the S.D.C. operator and attendant and a standby diver and his attendant. In carrying out an oxy-helium dive the procedure is, in outline, as follows: the S.D.C., in which is carried an attendant, is lowered to the depth of the diver's first decompression stop—in the case of a 450 ft. dive this would be 200 ft. below the surface. Supplied with compressed air, the diver—who has checked his equipment thoroughly for satisfactory operation and freedom from leaks—descends rapidly down the shot rope to a depth of 120 ft.

COMMUNICATIONS

Throughout the dive, the diver has telephone communication through a loudspeaker with the operators in the diving flat. At this depth, the main panel controller changes the supply from air to oxy-helium mixture, the proportions of which have been predetermined and tested in the ship's laboratory; the diver, meanwhile, audibly counts up to about 40, and when he begins to sound like Donald Duck—a consequence of the lower density of helium—the controller knows that he is receiving the oxy-helium mixture satisfactorily. He is then instructed to continue his descent to the bottom.

Special precautions are taken in the deep-diving dress to ensure that the concentration of carbon dioxide in the diver's helmet is kept to a minimum.

The " shot " on the end of the rope, incidentally, takes the form of a work-table equipped with a vice, tools and materials, bins, etc.

On ascending, the diver is hauled up by his breast-rope—by hand—until he reaches the ladder giving access to the S.D.C. The S.D.C. attendant removes the diver's helmet and equipment, and after the diver has climbed into the chamber the lower door is closed rendering it watertight and independent of the pressure outside. The chamber is then hoisted into its hold on the deck, pressure being reduced inside it in accordance with the decompression schedule. At the pressure equivalent to a depth of 30 ft., the diver is put on to a supply of pure oxygen for some 2 to 3 hours in order to speed up the elimination of helium. Except in dives to extreme depth, when the diver may have to spend up to 11 or 12 hours on decompressing, this then completes the diver's decompression; but the attendant, who has been subjected to air pressure equivalent to 200 ft. and who has not had access to pure oxygen to expedite his nitrogen elimination, requires further decompression, and in order to do this, on emerging at atmospheric pressure from the S.D.C., he transfers himself rapidlywi—thin one minute—to the recompression chamber in the diving flat, where the process is completed in comparative comfort.

AIR AND OXY-HELIUM PLANT

The engineering plant supplying the diving services is below deck. Dry compressed air is supplied to the control panels for the diver's supply, the S.D.C., and the recompression chamber through reducing valves from a ring main incorporating six large air storage bottles (about 9 cub. ft. free-air capacity each) charged, by way of a drying column, to 4,000 lb. per sq. in. by two electrically-driven Reavell four-stage compressors. Also housed in the air-compressor room are the three main oxygen storage bottles, of similar capacity.

In a separate flameproof room is the oxy-helium mixing plant comprising a 3,600 lb. per sq. in. water-cooled Hamworthy compressor, the drive motor for which is outside the flame-proof compartment and is remotely controlled, and all cylinders of which are fed with water for lubricating the piston rings and to eliminate the possibility of grease entering the cylinders. Dry helium drawn by the compressor from the standard industrial cylinders in which it is delivered to the ship, is stored in 12 storage bottles There are three banks of eight mixing bottles, each bank being used for storing a particular oxy-helium " brew " ; the standard brews are 9 per cent. O_2—91 per cent. He and 13 per cent. O_2—87 per cent. He. These bottles are topped up by the compressor as required after test samples have been analysed in the laboratory. From the mixture banks, the gas mixture is taken up to the diving control panels.

DEEP-DIVING DRESS

The deep-diving dress and the submersible decompression chambers used on H.M.S.Reclaim were made by Siebe, Gorman and Company, Limited, Chessington, Surrey.

In the deep-diving injector type of dress, the diver wears on his back a canister containing carbon-dioxide absorbent and an injector. The air (or oxy-helium) supply can be arranged either to pass through the injector, in which case it induces exhaled air from the diver's helmet to flow through the carbon-dioxide absorbent and then to recirculate with the surface supply, which can therefore be kept to a comparatively low value; or the supply can be arranged to bypass the injector, and in this case the diver's exhaled air escapes through the outlet of the helmet in the same way as it does in standard dress, a copious supply of air then being necessary. The diver's helmet is fitted with a rubber mouthpiece communicating with the canister and, with the injector bypassed, the diver can exhale directly into the absorbent to keep down the CO_2 concentration in his helmet.

During descent the injector is bypassed since, when the latter is opened, the gauge readings on the control panel in the diving flat do not give a true indication of the diver's depth and, therefore, the operators could not control the supply according to the diver's needs. Moreover, while descending the diver needs a plentiful air supply to compensate for the rapidly increasing external pressure. Once the diver is on the bottom, he opens the injector on receiving telephone instructions from the surface.

One other piece of equipment which should be mentioned is the deep-sea observation chamber, a pressure-tight chamber with a regenerative air supply at atmospheric pressure, in which most of Reclaim's divers have, this year, descended to 1,000 ft. below sea level—deeper than they have ever penetrated before. Deep-sea observation chambers have proved to be of great value in directing salvage operations at depths where divers in flexible dress cannot linger.

SAVING YOUR FUEL OIL

In this column we give the substance of a leaflet compiled by the Federation of British Industries (in co-operation with the National Industrial Fuel Efficiency Service) to assist users of fuel oil during the present critical period. Copies may be obtained from the F.B.I., 21 Tothill-street, London, S.W.1.

As a first step, appoint a responsible person to exercise a watching brief over all activities which influence oil consumption, either directly or indirectly.

Steam Raising

1. Keep a daily record of oil consumption.
2. Check the settings of the burner equipment. These should be in accordance with the makers' instructions.
3. See that the combustion air-control is correctly adjusted at all times. The CO_2 instrument is a valuable guide to this.
4. Examine boiler and economiser settings for air leaks. Air infiltration cools heated surfaces.
5. Ensure that heating surfaces are clean on both gas and water sides. Scale should not be present if the feed water conditioning is correct.
6. Check the amount of blowdown. This should be in accordance with the requirements of the feed water conditioning.
7. Avoid light loads or overloads. Re-arrange process timings and schedules where possible to maintain steadier conditions.
8. Investigate whether the boiler pressure is being maintained at the lowest possible level. Pressures higher than required increase the heat losses.

Steam Utilisation

9. Avoid using higher process steam pressures than are actually required. Try the effect of progressively reducing the pressure by 1 lb. steps.
10. Overhaul steam traps. Repack leaky glands. Examine joints for leakage.
11. Repair defective lagging, and insulate all bare surfaces.
12. See that isolating valves on steam and hot water lines shut off tightly.
13. See that boiling pans and vessels are covered.
14. Maintain a check on temperatures of heated liquids and air, and see that they are no higher than they need be.

Furnaces

15. Investigate the degree of loading. Re-arrange production schedules where possible to ensure loading to maximum capacities.
16. Reduce outside surface temperatures by the addition of a layer of insulating bricks or other suitable medium.
17. Investigate whether operating hours can be reduced by later lighting up and earlier shut down.

Space Heating

18. Instal thermometers at strategic points as a guard against overheating.
19. See that automatic controls are functioning correctly.
20. Replace broken windows and repair leaky walls and roofs.
21. Maintain a check on the opening of doors, and windows.
22. Apply the " degree " method of control.

Domestic Hot Water

23. Maintain a check on waste.
24. Control the temperature to the practicable minimum.
25. Limit availability to fixed periods.

ENGINEERING CONTRACTS

9—WHEN VARYING THE WORK IS REQUIRED

By F. H. B. Layfield

This is the ninth article of the series being contributed by Mr. Layfield for the guidance of engineers and others engaged on the preparation of engineering contracts. The eighth article appeared in ENGINEERING, *November* 9, 1956, *page* 585.

At the time when an engineering contract is signed the contract work has usually been carefully defined, often in very great detail. Yet that work is very rarely carried through to completion in precisely the form in which it was originally intended. Sometimes, unexpected eventualities render it difficult, if not impossible, to carry out the work in the way at first conceived. On other occasions, the engineer may wish to take advantage of previously unforeseen ways of improving the design of the work, as the actual construction progresses. It is, therefore, important to the engineer to ensure that he has the necessary authority to make alterations to the work and also that an efficient procedure will be followed in putting into effect any alterations that he may order.

The engineer has the power, whether expressly given or not, to see that the contract work is carried out as defined in the contract. If such a power is not set out in the contract, the law will imply it. The law will not, however, give the engineer implied power to alter the work; indeed, it will not even grant him implied authority to order extra work to be carried out which it is obvious is impliedly included in the contract specification. What is more, if the engineer either expressly or impliedly misrepresents to the contractor the extent of his authority to order variations the contractor may have a right of action against him.

It follows that, if the engineer desires to be able to make any addition, omission or alteration in the contract work, he must look for such power in the contract itself. The authority which he has to make such variations will be precisely that which the contract explicitly gives him. Clearly, therefore, the path of safety lies in the inclusion of a clause which will give him all the authority which he believes he is likely to need in connection with the work covered by the contract in question.

LIMITS TO ENGINEERS' POWERS

When the engineer is considering the scope given to him by the variation clause in a contract he will be well advised to bear in mind some of the likely limitations which there may be to his power to vary the work. The first question which the engineer may naturally ask is how extensive can the variations be which he is entitled to order under the variation clause? It may be said at once that any change in the work which is plainly designed to secure the speedy and effective completion of the contract work, as originally agreed upon, will come within the terms of almost any variation clause.

It is only when a variation is ordered which goes substantially outside what was originally agreed that difficulties arise. When considering this problem the basis of the law of contract is relevant. The foundation of contract in English law is *consensus*, i.e., an agreement between the parties. In an engineering contract, the underlying agreement between the parties is the undertaking to carry out certain specified work. Broadly speaking, one party undertakes to do the work while the other agrees to pay to have it done. If, however, work is required to be done under the contract, which is something radically different from that originally contemplated by the parties, such work may be outside the terms of the contract. It may be useful, therefore, to consider more fully how far the engineer may go in ordering variations to be made in the contract work.

It should in the first place be remembered that the contractor is under no obligation to carry out variations ordered by the engineer, unless such variations are expressly authorised in the terms of the contract. Where variations are so expressly authorised, they may yet be outside the scope of the contract. In order to prevent unnecessary disputes as to whether an order is outside the scope of the contract or not it is sometimes useful to agree on an ascertainable limit.

This is often done by providing that the effect of any variation, taken together with all other variations, shall not alter the contract price by more than a given percentage.This is the method adopted in several of the standard forms prepared by the Institutions of Mechanical, Electrical and Consulting Engineers. For example, in their form " B3 " it is provided that

> " The engineer shall have full power . . . from time to time during the execution of the contract by notice in writing to direct the contractor to alter, amend, omit, add to, or otherwise vary any of the works, and the contractor shall carry out such variations . . ."

This power is made subject to an express proviso which states

> " Provided that no such variation shall, except with the consent in writing of the contractor, be such as will, with any variations already directed to be made, involve a net increase or decrease in the contract price of more than 15 per cent. thereof."

Substantially the same limitation is set out in the " B1 " and " B2 " forms, except that the limit is there stated to be 10 per cent. of the total price payable. It should be noted that, in these two forms last mentioned, the limitation is only that " no such variation " shall exceed the limit. No mention is made of the effect of any previous variation.

DANGERS OF WIDE VARIATIONS

However any such limitation may be fixed, it is a very useful arrangement. There is, of course, no magic in the figures of ten or fifteen per cent., and the parties may settle upon any figure they regard as suitable. This ascertainable limit does prevent many arguments about the extent of the variation power. An alternative method is that used in the Institution of Civil Engineers' General Conditions. In those conditions, the power given to the engineer is to " make any variation of the form, quality or quantity of the works or any part thereof that may in his opinion be necessary " and also he is expressly authorised to " change the character, quality or kind of any such work."

This power is very widely expressed and authorises significant changes in the nature of the work originally contemplated. Under such a power, the engineer would seem to be able to make very considerable changes in the work. Yet, even here, the power is not unlimited; even with such wide phraseology, it is likely that the courts would recognise that the moment would come when a variation had gone beyond what was reasonably contemplated in the original contract.

It may well be asked whether the engineer should worry about exceeding the original contract terms provided always that the work he desires to see done is carried out ? In such an eventuality, the courts may hold that, the work having been done, it was done under a *substituted* contract. Normally, such a claim would be upon the basis that all the work ordered within the contract be paid for at the contract rates and any work outside it on a *quantum meruit*. Yet, in the words of Lord Kenyon,

> " if a man contracts to work by a certain plan and that plan is so entirely abandoned that it is impossible to trace the contract and to what part of it the work shall be applied, in such a case the workman shall be permitted to charge for the whole work done by measure and value, as if no contract had ever been made."

So that, if the original contract work was contracted on terms favourable to the employer, the employer might find himself paying more on a *quantum meruit* than he might think desirable. Secondly, the terms to be implied in a substituted contract are by no means necessarily the same as those in the original contract, and thus, in important matters, such as the damages declared to be payable in the event of delay, the employer might find himself at an unexpected and unwelcome disadvantage.

The question whether variations take the work outside the scope of the original contract is one of fact, having regard to the terms of the contract itself. It is, of course, quite permissible for the parties to agree that work not within the scope of the original contract, and not empowered to be ordered under the variation clause, shall, nevertheless, be executed under the same terms as those of the original contract. It need hardly be said that any such substituted agreement should, if possible, be in writing. But, when all has been said, the best advice for the engineer is that he should watch with care any exercise of his powers to vary the contract works, whenever that exercise may make a serious or substantial departure from the original scope of the contract.

FORM OF ORDERS TO VARY

If the engineer desires to order a variation of the works which is within his powers, the most important matter is to decide how the order should be given and carried into effect. It is normal to provide that a variation order should be given in writing. Thus, the Institution of Civil Engineers' General Conditions provide that " No such variation shall be made by the contractor without an order in writing of the engineer "; the " B3 " form, already mentioned, provides similarly that the engineer's power is to be exercised " by notice in writing."

It is highly desirable that provision be made in the contract, if at all possible, as to what the form and content of such a written variation order shall be. At the least, the engineer will be wise to establish for himself a clear form of the order which he intends to use. These precautions will avoid unnecessary arguments, which often arise, when the contractor receives from the engineer some such document as a signed sketch or a loosely worded letter.

Even with good will on both sides, it is sometimes very difficult to decide whether such a document constitutes a variation order. If a signed sketch is received by the contractor from the engineer indicating work found not to be within the original contract work, it is likely that a document of this kind will be regarded as a variation order. The engineer can best protect himself by establishing a standard form of variation order, and by making it abundantly clear that he will give a variation order in no other form.

CONFIRMING VERBAL ORDERS

Even where it is provided that a variation order must be in writing, the contract sometimes goes further and allows a verbal order to be given which is to be confirmed in writing. The Institution of Civil Engineers' General Conditions, for instance, having first said that a variation order must be in writing, then continues

> " Provided also that if for any reason the engineer shall consider it desirable to give any such order verbally the contractor shall comply with such order and any confirmation in writing of such verbal order given by the engineer whether before or after the

carrying out of the order shall be deemed to be an order in writing within the meaning of this clause."

The clause, which may perhaps be thought to be a shade verbose, does not stop there, but continues

"Provided further that if the contractor shall confirm in writing to the engineer any verbal order of the engineer and such confirmation shall not be contradicted in writing by the engineer it shall be deemed to be an order in writing by the engineer."

It may well be that the technical needs of modern engineering require such rapid alterations of carefully considered work that a procedure of the kind set out above is an essential thing. It should, however, be recognised that it is a procedure which teems with potential sources of argument and trouble. It may not be without significance that the forms issued by the Institutions of Mechanical, Electrical and Consulting Engineers manage to avoid making any provision for verbal variation orders. The numerous dangers of such orders are too obvious to require mention and, clearly, they are best avoided whenever this is at all possible.

There are other related dangers which may arise when variation orders are issued and which the engineer should keep in view. In the event that a contract provides for variations to be kept within a limited margin of, say, a 10 per cent. alteration in the contract price, the engineer will no doubt wish to have warning when the contractor considers, rightly or wrongly, that this state of affairs has arisen. It is useful to have in the contract a stipulation that, unless the engineer is notified by the contractor that he considers that this limit will be exceeded if a particular order is carried out, the limit shall be deemed not to have been exceeded. On the other hand, even quite small variations in the contract work may affect the obligations of the contractor; and especially is this likely when the works are very large and complex.

The engineer may often wish to know if the contractor considers that a variation order will have this effect. To meet this desire some forms of contract provide that

"If in the opinion of the contractor any such variation is likely to prevent or prejudice the contractor from or in fulfilling any of his obligations under the contract, he shall notify the engineer thereof in writing, and the engineer shall decide forthwith whether or not the same shall be carried out. If the engineer confirms his instructions in writing, the said obligations shall be modified to such an extent as may be justified. Until the engineer so confirms his instructions they shall be deemed not to have been given."

This kind of provision prevents unexpected claims being raised long after a variation order has been given.

PAYING FOR VARIATIONS

One of the most vital aspects of the procedure for varying the contract works is that of payment. The contract should describe carefully the way in which the value of varied work is to be ascertained. If the work involved is of a kind for which a rate or rates are already specified, the contract will usually state that such rates are to be applied, whenever that is reasonable. The provisions which really require careful scrutiny are those which deal with work for which no applicable rate is set out in the contract.

The real difficulty is to make advance provision for work, the need for which, in the nature of the matter, was not originally foreseen. The standard method of meeting this difficulty is to state that the engineer "shall fix such other rate or price as in the circumstances he shall think reasonable and proper." Often this is the best that can be done, but, whenever reference can be made to some ascertainable code of prices, that is a much more satisfactory method. In some cases, for example, day work may be applicable, and these instances can be dealt with in accordance with the schedules issued by the Federation of Civil Engineering Contractors.

In addition to the need to provide, wherever possible, a detailed method of valuing varied work it is also desirable to state the procedure to be followed in making the actual claim for any extra payment and, of course, for making any deduction due to work omitted. The way in which variation payments should be claimed and the time to be allowed for making such claims vary greatly from contract to contract and depend upon local conditions. The engineer should satisfy himself that the procedure adopted will meet the specific requirement of each particular contract and enable him to keep a sufficiently close watch on changes which have been effected by variation orders.

SUMMARY

Few engineering contracts are carried through to a successful conclusion without some alterations, whether small or large, to the work as originally defined. The engineer has no implied power to make these changes and any such power must be expressly stated in the contract. The engineer will be strictly limited to such power to vary as is described in the contract; how extensively he may wish to be able to use the power to vary the contract works should be considered when the contract is prepared.

Sometimes it will be wise to indicate express limits which both parties can clearly comprehend. But, even if very wide powers are taken, the engineer should beware of the limits attached to their exercise. Even a widely phrased clause giving him power to vary extensively may not justify him in ordering changes which will radically alter the scope of the original contract. If he exceeds the variations allowable under the contract this can have unfortunate effects. The price to be paid for the additional work may be higher than expected and, if done under a new implied contract, may be executed under terms other than those originally contemplated.

When power to vary is exercised, it should, whenever possible, be done by written order. Verbal orders are subject to many difficulties and are to be avoided. Unless absolutely necessary, it may be wise not to include in the contract a power to give a variation order verbally. Even when the power is exercised in writing, the order should be carefully drawn. Probably the best method to adopt is to have a standard form of order appended to the contract which is then always to be used. This method makes it difficult for vague letters or sketches to be construed as variation orders, and ensures that the order will contain all the necessary details to enable it to be put into action with the least difficulty and danger of ambiguity.

Variations in the work to be done usually mean corresponding variations in the contract price. The contract should make provisions for the valuation of such variations. These provisions should specify rates for work similar to that originally contemplated and also, if possible, for work of kinds not originally foreseen. The latter need can sometimes be met by reference to a general code of prices. Finally, a clear procedure needs to be established by which claims for changes in the contract price can be notified and settled.

TESTING TOUGHENED GLASS INSULATORS

ELECTRICAL, THERMAL AND MECHANICAL STRESSES

Although glass insulators have been used on "weak current" circuits, especially on the Continent, for many years, it was found that the original patterns were neither of sufficient mechanical nor electrical strength to enable them to be employed on power lines. In 1935, however, it was discovered by Pilkington Brothers, Limited, St. Helens, Lancashire, that these drawbacks could be overcome by making use of toughened glass and, although at first a number of teething troubles had to be overcome, especially in matching up the properties of the glass with the necessary metal fittings, insulators made of this type of material are now receiving a wide application, especially for the highest voltages. For example, the 1,000-mile line of the Kariba scheme, which is to operate at 330 kV, will be carried on about 30,000 glass insulators. When the present full commitments of the laboratory are complete, it is probable that its facilities will be made available for contract work or for co-operative research.

The advantage of toughened glass as an insulating material may be roughly stated to be that its electrical strength is about 3½ times that of porcelain. Moreover, if one of the elements in a string becomes defective the glass shed will fall away and its absence can easily be detected by inspection from the ground. This property, it is claimed, is unique to toughened glass and makes the detection of a fault much easier.

A perhaps natural result of this development is that it has been found necessary to build a special laboratory for testing toughened glass insulators at the Ravenhead Works of the firm. This laboratory, which was formally opened by Lord Citrine on November 2, has been designed so that research and development work can be carried out with the object of improving the performance of both insulators and strings. It will also provide customers with technical services to ensure that the insulator string arrangements meet their specifications, and will make electrical and mechanical tests in accordance with the appropriate British Standard and other specifications, including the international specification for glass insulators which it is expected will shortly be issued.

HIGH VOLTAGE TESTS

The laboratory consists mainly of a large hall, 120 ft. long by 80 ft. wide by 60 ft. high, a general view of which, from the north end, is given in Fig. 1, opposite. Most of the floor space in this hall is devoted to high-voltage testing, but there is a perimeter passage which is isolated from the testing areas by a metal safety fence with interlocking devices. In addition, there is a two-storey office block, on the second floor of which is a soundproof room. This room overlooks the hall through a large observation window. Mechanical testing plant, a dark room, substation and storage spaces are housed in annexes. The building is naturally lighted through 2,500 sq. ft. of vertical glazing arranged at the top of the side walls; it can, however, be completely darkened in about 15 seconds for the observation of corona effects. To minimise idle time all handling of the insulator strings is motorised.

Facilities are provided for carrying out high-voltage tests with either impulse or power frequency voltages, and on both vertical and horizontal strings of insulators. For this purpose the vertical strings are suspended from the ceiling and can be raised or lowered by electrically-operated hoists. Horizontal strings are stretched across the laboratory by means of three-ton winches and their height above floor level can be adjusted to a maximum of 40 ft. A string of insulators, which is being assembled prior to electrical testing in the horizontal position, is visible in the foreground of Fig. 1. The cable ends of horizontal strings are attached to wall stanchions.

Tests can be conducted either in the wet or in the dry, artificial rain for the wet tests being

Fig. 1 Toughened glass insulators of the type forming the string in the foreground can be impulse tested up to 2,300 kV by the 14 stage generator in the background. On the left are the 2 metre spheres forming the standard of voltage measurement.

supplied at a uniform rate through sprays suspended from the ceiling. The water used is previously passed through a demineralising plant so that its conductivity can be controlled.

Impulse voltages for test purposes up to a maximum peak value of 2,300 kV are generated by a 14-stage impulse circuit. Each stage of this generator consists of two 0·075 microfarad condensers, the maximum charging voltage being 170 kV on either polarity. The output voltages appear across a 235 microfarad wave-front condenser, which is also the high voltage unit of the potential divider from which all the connections to the equipment under test are made. All the earth connections in the impulse circuit terminate at the base of the potential divider, which is the reference point for all impulse voltage measurements.

VOLTAGE MEASUREMENT

The generator is normally adjusted to deliver a 1/50 micro-second wave, although wave shape parameters may be adjusted about this value by choosing suitable alternative wave front and wave tail resistance values. The generator is tapped at a predetermined value of the charging voltage by an electronic circuit. This also provides the tripping pulse for the cathode ray oscillograph, there being a controlled variable time-delay between the two.

The standard of voltage measurement is a sphere gap, 2 m. in diameter, which as can be seen on the left of Fig. 1, is arranged vertically. The upper live sphere is suspended from the ceiling by a long string of insulators and its height may be coarsely adjusted from floor level by a hand winch. Fine adjustment of the gap spacing is obtained by varying the height of the lower earthed sphere, this movement being controlled by a motorised screw-drive.

An alternative method of impulse voltage measurement is by the capacitor potential divider and a sealed-off cathode ray tube. Oscillograms of wave shape are then recorded on 35 mm. film. During a test all adjustments of the charging voltage, generator sphere gap and 2 metre sphere gap can be carried out from the control desk in the impulse control room, which is illustrated in Fig. 2. The sphere gap spacings are read from remote indicators on the control desk.

Power-frequency alternating-current voltages up to a maximum of 1,300 kV root-mean-square can be obtained from two 1,200 volt/650 kV testing transformers connected in cascade, one transformer being insulated from earth for 650 kV. The input to these transformers is supplied by a motor-generator set and tapped auto transformer; the output of both high voltage transformers is continuously variable between 14 kV and 650 kV. The voltages are measured from a voltmeter winding which is used in conjunction with the 2 metre sphere gap as standard. All the power frequency tests are controlled from a desk in a control room. The 2 metre sphere gap may be operated from either the 50 cycle or the impulse control desk.

MECHANICAL TESTING EQUIPMENT

The mechanical testing equipment in the laboratory is used to apply appropriate loads to all types of insulators and fittings, so that their behaviour under service conditions may be investigated. It includes an Avery tensile testing machine with a maximum capacity of 50 tons and a machine for testing post-type insulators, illustrated in Fig. 3, by which tensile, torsion, cantilever and vibrating cantilever loads may be applied to single or multi-unit posts. Further equipment for carrying out long-term mechanical tests is being installed.

In addition to the main electrical and mechanical tests, the new high-voltage laboratory is responsible for the sample testing of each consignment of cement used in the assembly of the insulators and for the sample testing of the galvanising of all ferrous metal fittings. It is also used for the thermal cycle testing of insulators, for which purpose four water baths arranged in pairs have been provided. Two of these can be heated to temperatures up to 96 deg. C. and the other two cooled to 1 deg. C., thereby permitting the complete range of temperature difference called for in the various national specifications for insulators to be obtained. The charge of insulators is housed in metal cages, which are transferred from the hot to the cold bath and vice versa by motorised pulley blocks.

The laboratory equipment was designed by Mr. E. F. Johnston and the staff of Pilkington Brothers in consultation with Metropolitan-Vickers Electrical Company, Limited, Manchester. The main electrical installation was supplied by the latter firm. The building was designed by Mr. C. C. Handisyde, A.R.I.B.A., and was constructed by Bovis Limited.

Fig. 2 Adjustment of charging voltage and of the spark gaps can be made from the control room. Photographic records are made of the oscillograph trace. The power-frequency transformers are on the left.

Fig. 3 In addition to the electrical tests, the insulators are subjected to mechanical tests and to thermal shock. Here a post type is being tested under cantilever loading.

ANALYSING DATA FOR DECISIONS

EXAMPLES OF OPERATIONAL RESEARCH

*By R. Solt**

When a man in authority is faced with a situation in which he must make a decision, what he does—or what he tells someone else to do—must always depend on the facts of the situation as he knows them. The less factual knowledge is available the more he must rely on estimates, intuition or "judgment," and the more he is liable to make a faulty decision. It is the aim of operational research to find out as much as possible about the relevant facts, so that decisions can be made on a sounder basis.

This article describes a few actual examples of simple operational research from various firms in the iron and steel industry. They serve to show how new and sometimes unsuspected facts may be brought to light by analysis of what was in most cases routine data, supplemented sometimes by specially-kept records. In no instance was there much work involved in collecting the necessary data, nor did their analysis need a highly specialised knowledge of mathematical methods.

In several of the cases described, the difficult part of the work consisted in discovering where the problem lay, or indeed that a problem existed at all. It was frequently found that established practice was based on some assumption which, in the event, proved to be incorrect. Once such an assumption had been made it was usually accepted as established fact, and was not questioned again. It needed an open mind and a questioning approach to locate the trouble spot.

QUALITY REJECTS

The first case concerns a plant in which the product, say steel rods and sections, had to fall within a closely-specified hardness range. This was achieved by giving each piece the appropriate heat treatment: after soaking for several hours at a prescribed temperature it was quenched, and was then reheated and tempered. The time for which each item was left in the soaking and the tempering furnace was matched to the size of the piece. Large sections were left in for longer than small, and the times ranged from 3 to 10 hours.

Every piece was checked for hardness after it was heat-treated, and if the specification was not met the piece had to be heat-treated again. About one piece in every ten had to be treated more than once before the correct hardness was achieved, and this reject rate of 10 per cent. was considered to be too high. An analysis was therefore made to determine the effect of heat-treatment practice on the hardness obtained. Several different factors which might have had some bearing on the results were investigated, but none yielded any positive results, until the effect of soaking and tempering times was considered. The following table sets out the results of this analysis.

TABLE I.—*Analysis of Rejects for Various Soaking and Tempering Times*

	Soaked for less than 6 hours			Soaked for more than 6 hours		
	Correct hardness	Too hard	Too soft	Correct hardness	Too hard	Too soft
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Tempered for less than 7 hours.. ..	83	10	7	74	25	1
Tempered for more than 7 hours.. ..	86	0	14	97	2	1

This analysis suggested that the correct heat treatment was to soak for over 6 hours before quenching and then to temper for over 7 hours. Of the pieces which received this treatment, only about 3 per cent. had to be rejected. Where the correct soaking time was followed by insufficient tempering, 25 per cent. of the pieces came out too hard. Where the soaking time was less than 6 hours, but was followed by a sufficiently long temper, 14 per cent. of the pieces came out too soft.

Thus, insufficient soaking caused pieces to be too soft, and insufficient tempering caused them to be too hard. If either of these effects predominated, rejects were produced. On the other hand, both effects could be present to about the same extent so that they cancelled out, and the correct hardness could be obtained. Such pieces were probably not as homogeneous as they should have been, though the test results complied with the specification.

The first results after all soaking and tempering times were lengthened to 6 and 7 hours respectively, showed a marked reduction in rejects. At the same time, the question arose as to why small sections, which had previously received only 3 to 4 hours, should require such prolonged heat treatment; subsequent work showed up possible causes of error in the temperature control of the heat-treatment furnaces, the rectification of which may make it possible to reduce the heat-treatment times of both small and large pieces.

FAULTY ESTIMATES

A second example concerns an open-hearth melting shop with an output which was well below capacity. Among several other reasons which could be pin-pointed, the following was the simplest and the most startling. At each charge, the furnaces were filled in the usual manner with loose scrap and pig iron until the furnace operator thought he had the furnace filled to capacity, say 100 tons. In this he was guided by the appearance of the charge in the furnace—whether it "looked full"—and by his estimate of the weight of successive lots of charge as they had been put into the furnace. These estimated weights were noted down by the furnace operator; they were not totalled up by him, but doubtless he made some mental summation before deciding whether the furnace was full. It was generally believed that furnace operators were able to guess charge weights reasonably accurately.

A fairly reliable guide to the actual weight charged was obtained from the number of ingots which were subsequently cast from each charge. When these weights were analysed the diagram of Fig. 1 was obtained. This showed that the individual cast weights varied from 30 per cent. below to 20 per cent. above nominal capacity,

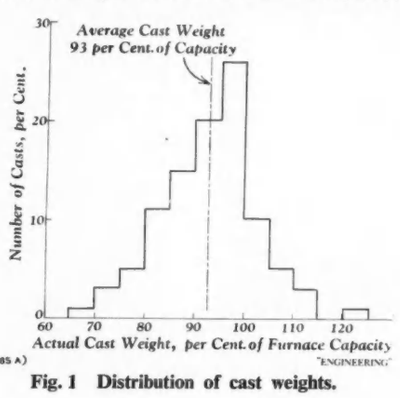


Fig. 1 Distribution of cast weights.

and that the average cast weight was 7 per cent. below capacity. The effect of this under-filling could be seen from the relationship of Fig. 2, which shows how the output rate drops when the furnace is not fully charged.

Several possibilities were explored in order to discover a reason for this consistent under-filling. Among others, the charging records of each cast were collected, and the estimated weights were totalled for comparison with the actual weights cast. These comparisons showed that over-estimates of weight charged were in fact associated with under-filled furnaces, and vice versa. This confirmed the suggestion that furnace operators were actually unable to guess charge weights correctly, and that the wide weight variation was largely due to faulty estimating. The output of this shop was subsequently raised by a substantial margin, and a large part of the rise was attributed to more care in filling the furnaces to capacity at each charge.

ANALYSIS OF DELAYS

In another melting shop—a very efficient one—the question arose as to whether it would pay to bale scrap for ease in charging. A baling press is an expensive item of equipment, and the economies which its use would bring about were not quite clear.

The advantage of prepared scrap is that it is easier to handle, and it is therefore easier to keep furnaces supplied with charge. It was agreed that any major economy could only follow from increased output of the furnaces, achieved by cutting down on delays during charging. It was known that such charging delays did occasionally happen, and the furnace operators had instructions to record them. These records were analysed: operators had estimated charging delays to the nearest 10, 15, 20, and 30 minutes and thereafter in 15 minute steps; the recorded delay frequency is shown in the block diagram of Fig. 3.

In practice one would expect frequent short delays and occasional long ones, but because little importance was attached to delays of 20 minutes or less they often went unrecorded. To get a full picture of all delays it was therefore necessary to extrapolate from the reliably recorded long-delay region back into the short-delay region.

Such an extrapolation could obviously not be done with any confidence from the data as presented in the block diagram of Fig. 3. Consideration of the nature of these delays indicated, however, that their frequency distribution should follow a logarithmic die-away curve. In fact, a straight-line graph could fairly be obtained if the "number of charges delayed" was drawn to a logarithmic scale, as in Fig. 4. The "calculated" curve of Fig. 3, on the opposite page, represents this same line drawn to a linear scale.

The analysis now became quite simple. The straight line of Fig. 4 is defined by the equation:

$$\log_e n = k - a t \quad . \quad . \quad (i)$$

where n is the number of charges, k the intercept of the line on the y-axis, a the slope of the line, and t the delay time.

From (i), $n = e^{k - a t}$.

The total number of charges affected by

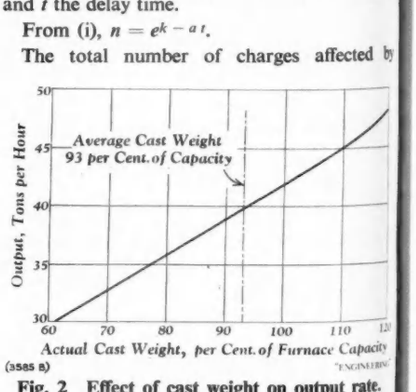


Fig. 2 Effect of cast weight on output rate.

* Mr. Solt was until recently head of the Advisory Service of the British Iron & Steel Research Association (Operational Research Section).

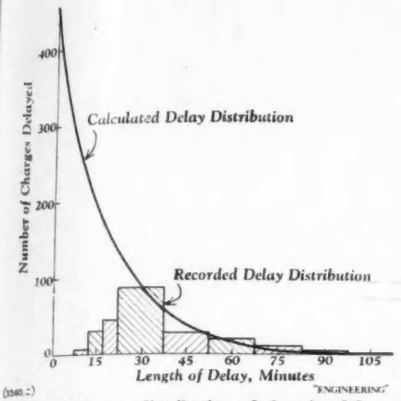


Fig. 3 Frequency distribution of charging delays. (Total sample—1470 charges)

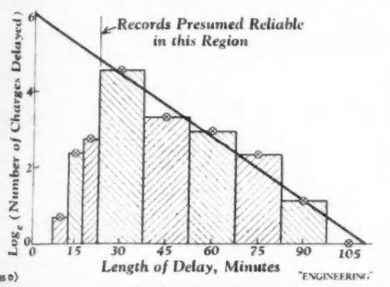


Fig. 4 Frequency distribution of charging delays:- logarithmic relationship.

delays, N, is therefore

$$N = \int_{t=0}^{t=\infty} n\,dt$$

$$= \int_{t=0}^{t=\infty} e^{k-at}\,dt$$

whence $$N = \frac{1}{a}e^{k} \quad . \quad . \quad . \quad . \quad . \quad \text{(ii)}$$

The total time lost due to charging delays, T, is similarly found by summating all delays t which affect corresponding numbers of n charges:

$$T = \int_{t=0}^{t=\infty} t\,n\,dt$$

$$= \int_{t=0}^{t=\infty} t\,e^{k-at}\,dt$$

and $$T = \left(\frac{1}{a}\right)^{2} e^{k} \quad . \quad . \quad . \quad \text{(iii)}$$

The results of this analysis could be presented as in Table II.

TABLE II.—*Analysis of Charging Delays*

—		Calculated	Recorded
From graph:			
Slope	a	0·764	
Intercept	k	6·1	
Number of charges affected by delays	N	585	175
Portion of all charges affected by delays (total sample—1,470 charges)		40 per cent.	12 per cent.
Total delay during 1,470 charges	T	193 hr.	110 hr.
Average charging delay per charge		7·0 min.	4·5 min.

These results show that the records, by omitting the bulk of short delays—and it can justifiably be assumed that they did—understated the total time lost by nearly a half. The analysis provided a more acceptable basis for determining the time lost by charging delays, and therefore the scope for saving time by scrap preparation.

MINIMISING SCRAP

This last case concerns a cold-rolling works which used wide strip for slitting down into 12 narrow (say 3 in.) bands before further cold-rolling. For a 36 in. width of useable strip to be ensured, a 36½ in. wide strip had to be fed into the slitting shears to give a ¼ in. shearing margin on each side. Strip was therefore ordered " not less than 36½ in. wide."

In the course of some other work on the site it was noticed that the side shearings, which were lying about for collection as scrap, seemed unnecessarily wide. Further investigation showed that the suppliers of the wide strip added their own plus tolerance, and the strip was actually delivered much more than 36½ in. wide. A number of coils were therefore measured for width, and the distribution obtained is shown in the block diagram of Fig. 5. Out of more than 100 coils measured, only two were less than 36⅞ in. wide, i.e., less than ⅛ in. oversize. The average width of all strips was ¼ in. oversize. All this extra width had to be paid for (since strip is bought by weight), but it merely produced extra scrap. The problem was therefore whether the maker's tolerance could be taken into account when ordering, and to find the width at which strip should be ordered.

A normal distribution of strip width was calculated to fit the measured data. It is shown as the smooth curve in Fig. 5 and represents the distribution of widths which would probably be obtained if a very great number of strips were measured.

From this normal curve, it was possible to say that strip could be ordered at ¼ in. less wide (at " not less than 36⅜ in.") without any risk whatever of getting a coil less than 36½ in. wide. If coils were ordered as much as ¼ in. less wide, some three coils in every 1,000 might be too narrow for satisfactory shearing. In that case, three 3 in. bands would have to be scrapped—but ¼ in. of material would be saved on each of the remaining 997 coils. It would, therefore, be an obvious saving to accept some risk of an occasional narrow coil. The position is set out in Table III.

TABLE III.—*Total Scrap Loss with Different Coil Widths*

Width ordered	Average width supplied	Average width of off-cut per 1,000 coils	Probable number of rejects per 1,000 coils	Probable width lost (3 in. bands) per 1,000 coils	Probable total scrap loss per 1,000 coils
In.	In.	In.		In.	In.
36½	37½	750	0	0	750
36⅝	37⅛	625	0	0	625
36¼	37	500	3	9	509
36⅛	37⅛	375	23	69	444
36	36⅛	250	104	312	562

The total scrap loss is made up of the material lost through side shearings on every strip (off-cut), plus the loss of an occasional 3 in. band when the original strip is too narrow for satisfactory shearing. The figures of Table III showed that the least overall scrap loss would occur if strip were ordered 36⅛ in. wide. Compared with ordering it at 36½ in., when a total strip width of 750 in. was lost for every 1,000 coils sheared, the total off-cut would only be about 444 in. or 60 per cent. of the previous figure. The analysis therefore enabled the works to save about 40 per cent. of their off-cut scrap.

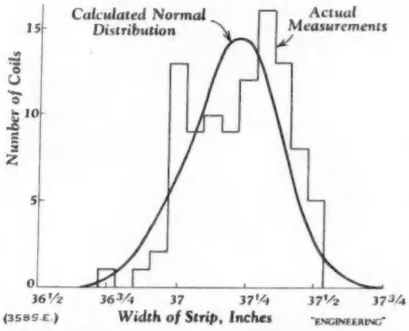


Fig. 5 Distribution of strip widths when ordered " not less than 36½ inches wide."

The preceding examples are intended to convey an idea of some kinds of problem which may be tackled and of the methods which may be employed. Whether their solution was in actual fact achieved by operational research methods, by statistical analysis, or by plain common sense, is as arguable as it is irrelevant. The point is that problems of this kind abound in industry, and that their solution pays dividends. It has already been mentioned that the difficulty frequently lies in recognising a problem and in finding its cause, while the mathematical solution is only rarely difficult. It is often a far cry, however, from the paper solution of a problem to its successful application; and there can be no brief for work of this kind unless its results can be and are actually put into operation.

The work described in this article was carried out in conjunction with Mr. R. H. Hannaford, Mr. R. G. Massey, and Mr. W. O. Pendray of the British Iron and Steel Research Association.

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WATER, COAL AND URANIUM

It is frequently said that coal is the only natural wealth of this country; this assertion omits water. Without ample supplies of this latter commodity the industrial activity on which the material prosperity of Great Britain is based could neither have been built up nor could it have endured. To try to estimate the relative importance of water versus coal would be a meaningless task but the importance of both is indicated by the fact that last year of 1,270 boreholes sunk 514 were for water and 631 for coal. Of the remaining 125, 29 were sunk in the hopeful, or hopeless, search for gas and oil, 90 covered all other minerals and six were geological survey boreholes. These figures are given in the Geological Survey Summary of Progress for the year 1955, but the report does not give much information about the results obtained from these extensive activities. The boreholes sunk in the search for coal were part of the programme of the National Coal Board; development following any results obtained is a matter for that authority. The interest of the Geological Survey lies in the information obtained about strata, furnishing data for incorporation in geological maps.

The boreholes sunk in the search for water are, in general, relatively shallow and do not supply very much geological information. Their importance in the industrial development of the country is, however, great, for the scattering of industrial establishments over the length and breadth of the land requires that adequate information should be available about water reserves in localities in which development is proceeding or is planned.

The Geological Survey incorporates an atomic energy division and the report gives some information about the search for raw materials. It would certainly make a fundamental change in the natural wealth of this country, *vis-à-vis* some other parts of the world, if economically-exploitable supplies of the raw materials of atomic energy were to be discovered here. On this matter, however, the report is not promising. The search for uranium is being continued, particularly in Devon and Cornwall and new, but small, occurrences have been found. Traces were also discovered in an old lead mine in Perthshire, but it is not thought that the deposit is likely to prove of economic importance. The atomic energy division has also been concerned with the inspection of deposits in Canada, Australia and Nyasaland. The most important development reported is the formation of a British-Canadian company to work deposits in the Blind River area in Ontario. It plans to produce 200 million dols. worth of uranium precipitate in the next five years.

"XEROGRAPHY"

PHOTOGRAPHY SUPERSEDED?

The introduction of a new technique of producing copies was recently announced by the Rank Organisation, which has formed a new company—Rank-Xerox Limited, in association with the Haloid Company of Rochester, New York. Xerography, which is proving very successful in the United States, is a dry electrostatic method of reproduction. It is similar in many respects to photography, but uses electrical forces and dry powders instead of sensitised emulsions to produce images. The surface of a selenium-coated plate is given a positive charge prior to use. The plate is then exposed in a camera and the positive charges on the plate disappear in areas on which light falls (where no image is projected). A negatively-charged powder is then blown over the plate and adheres to the positively-charged image. A sheet of paper placed over the plate receives a positive charge, with the result that it attracts powder from the plate thus forming a direct positive image. The print is then heated for a few seconds to fuse the powder. It is extremely rapid and economical and makes possible the use of almost any type of paper without any pre-sensitised coating. In the United States it is being used extensively for office work and the reproduction of engineering drawings. It has also been applied to X-ray work, reproduction of electronic computations, and high-speed offset printing. In this country it has mainly been developed for radiography but the comparatively long exposure times at present needed tend to limit its use to the radiographing of the body extremities.

Rank's announcement suggests that they have found an answer to at least some of the simplest as well as the most exacting requirements for reproduction purposes. Rank-Xerox are starting manufacture of xerographic equipment in this country and intend to export to world markets outside the United States and Canada. Supplies will become available early next year. Meanwhile they are setting up a copying service—in St. Andrews House, Mortimer-street, W.1—which will be in operation before the end of this year. It will specialise in the bulk-reproduction of micro-film records on continuous rolls of paper but will also include the preparation of offset-litho paper masters—both low-cost masters made by automatic methods and hand-made masters for general duplicating on office-type offset machines.

CUTTING THE COSTS OF IRON AND STEEL

In an endeavour to meet the ever-growing demand for its products the iron and steel industry of this country has increased its productivity by 41 per cent. between the years 1946 and 1955. In "Productivity Review No. 27" dealing with iron and steel, issued by the British Productivity Council, 21 Tothill-street, London, S.W.1, it is stated that the prices of the principal products of the steel industry in the United Kingdom are still significantly below the home prices in foreign countries and notably below prices in the United States.

The drive for fuel efficiency has borne fruit, as is shown by the ironmaster's "yardstick" of measurement, namely the declining coke consumption in the blast furnace, per ton of iron produced. It is pointed out that all the ore-preparation processes, now being increasingly employed, require some use of electric power or low-grade fuel, but that the expense of the fuel so consumed is greatly outweighed by the saving effected through increased blast-furnace efficiency. Thus, one large works operating on the leanest home ore had a coke consumption of about 27 cwt. a ton of iron when raw ore was used; by partial preparation of the ore the figure was reduced to 22 cwt., and, by full preparation of the burden, to less than 18 cwt. One blast furnace, by special preparation, had lowered its average still further to 15 cwt. of coke per ton of pig iron. This experience has been repeated in varying degrees at the many works where ore-preparation facilities have been extended in recent years.

Taking overall figures, the coke used, per ton of basic iron, has been reduced by 13 per cent. since the war, *i.e.*, from 22 cwt. in 1946 to 19 cwt. in 1955. The fuel consumed, per ton of finished steel, which is a measure of fuel economy over all the stages of production, has been reduced by 9 per cent. since 1948, namely from 37·9 cwt. of coal (and coal equivalent) per ton of finished steel to 34·4 cwt. in 1955.

The average output of basic and hematite pig iron, per blast furnace in operation, has risen by 63·7 per cent. since the war. The total output increased from 6·4 million tons in 1946 to 10·7 million tons in 1955, although the number of furnaces in blast has remained virtually the same.

The average output per open-hearth furnace has risen by 63·3 per cent. since the war. Total production rose from 11·1 million tons in 1946 to 17·3 million tons in 1955, while the number of furnaces in operation has fallen from 302 to 287.

In addition to increasing the output of steel, existing steels have been made to do more work by the evolution of new techniques of shaping the material and the encouragement of more efficient design. Moreover, new steel alloys or new uses for older alloys have enabled some applications to be better accomplished.

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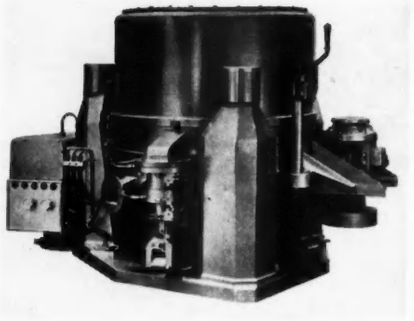
CONTINUOUS DE-OILING OF SWARF

Centrifuge with Automatic Discharge

The "Ellerwerke" continuous swarf-oil separator which is now being supplied in the United Kingdom by Sharples Centrifuges Limited, Tower House, Woodchester, Stroud, Gloucestershire, extracts the oil by centrifugal action, leaving no more than 1 or 2 per cent. of fluid in the swarf, which is discharged automatically. The machine is available in four sizes, the capacities, in crushed steel swarf, being approximately 1, 3, 5 and 8 tons per hour respectively. Proportionate amounts of other metal swarfs can be treated by the machines, the actual capacity varying slightly in all cases according to the bulk density of the swarf.



Oily swarf fed into the centre of the "Ellerwerke" continuous separator is traversed automatically up the wall of a centrifuge basket and pushed over the top to a discharge point when it is de-oiled.

The machine resembles an orthodox centrifuge, but is equipped with automatic swarf discharging gear. Mounted on the same vertical axis as the rotating basket is a feed and discharge ram, which is reciprocated hydraulically over a distance equal to approximately a quarter of the basket depth, at a rate of 10 to 12 strokes a minute. Oily swarf falls into the centre of the basket through a feed hopper, and is flung against the perforated basket wall by centrifugal force. When the central ram makes its up-stroke it pushes a quantity of de-oiled swarf over the top of the basket wall; this swarf is discharged at the bottom of the machine. As the ram returns to the bottom of its stroke a quantity of oily swarf replaces that which has just been discharged, the untreated material entering at the bottom of the basket. There is thus an intermittent movement of swarf from the bottom to the top of the basket, and over the top to the discharge point, the swarf losing its oil as it travels up the basket wall. The rate of movement of the feed and discharge ram is adjustable to suit the material being treated.

A feature of the machine is that the main working part of the unit is suspended from three pendulum bearings. The minimum of vibration is therefore transmitted to the foundations, high bearing stresses are eliminated, and the extractor runs smoothly.

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STEEL PICKLING AND PAINTING SERVICE

Recent developments at the Rose Mount Iron Works of Robert Dempster and Sons, Limited, Elland, Yorkshire, include a new pickling and painting shop which is now in operation and is dealing not only with the firm's own products but is available also to other companies in the engineering industry.

The new shop has been built for the pickling and painting of steel plates and sections, having a maximum length and width of 34 ft. and 7 ft., respectively, used in gas, chemical and oil plants and for general structures. In the process adopted, mill scale and rust are removed from the steel by immersion for some 15 to 25 minutes in a 5-6 per cent. sulphuric acid bath held at a temperature of 65 deg. C. After this, the superfluous acid is allowed to drain off and the steel is subjected to two dips in a water bath maintained at a temperature of 65 deg. C. After washing, the steel is finally immersed in a phosphoric acid bath maintained at 85 deg. C., and containing 2 per cent. of free phosphoric acid with from 0·3 to 0·4 per cent. of iron. This last immersion produces a rust-inhibiting coating of iron phosphate over the whole surface of the steel. When dry, and while still warm, the steel is painted with an appropriate priming coat well brushed in.

The three baths of the pickling plant are each 35 ft. long, by 5 ft. wide and 9 ft. deep; the shells are of reinforced concrete, lined on the inside with a rubber membrane and clad on the outside and inside with 9 in. thick acid-resisting brickwork, set in acid-resisting cement. The baths are heated by steam injectors and the effluent is neutralised before being discharged into the sewers so as to have a *p*H value of between 7 and 9 and containing not more than 40 parts of solids in 100,000.

Electric fans are used to extract fumes from the shop and to deliver fresh air towards the baths. This air is cool in warm weather and warm in cold weather, so serving the dual purpose of maintaining good conditions for the personnel employed and speedily drying the painted steel.

The shop is served by a 10 ton overhead electric travelling crane of the company's own make, augmented by two 5 ton mobile cranes at peak periods of unloading and loading. Special tackle has been designed to handle the varying types of materials to be treated and special racks are provided to facilitate painting.

ELASTIC STABILITY UNDER COMBINED LOADING

GENERAL EQUATIONS FOR "EULER" MEMBERS

By A. N. Procter, M.SC., A.M.I.C.E., M.I.STRUCT.E.

The method of calculation given below shows how an accurate estimate may be made of the buckling strength of a flexible structural member under a system of axial forces, bending moments and torques; also how the resulting secondary bending moments may be estimated. It is assumed that the properties of the materials remain approximately constant and that the cross-sections of the members are such that they will not fail by local buckling. The calculations are intended to apply to "Euler" members, but they may be adapted to apply also to stiffer members. The members are assumed to be initially straight.

Fig. 1 represents a flat slender member of length l with round or freely hinged ends, to which an axial force, F_A, a lateral bending moment, M_{Yy}, a transverse bending moment, M_{Xx}, and a torque, M_{Tt}, are applied. It is assumed that the deflection in the direction of buckling may be expressed in the form $y = y_0 \cos \frac{\pi x}{l}$, y_0 being the deflection at the origin, O, and x is the distance from O. The work done by the force, F_A, in producing a small lateral deflection, y_0, would be

$$\tfrac{1}{2} \int_{-\frac{l}{2}}^{+\frac{l}{2}} F_A \left(\frac{dy}{dx}\right)^2 dx = \frac{\pi^2 F_A y_0^2}{4l}.$$

Assuming the lateral slope, i, is produced at a point x from O by the lateral bending moment, $-M_{Yy}$, (here considered negative relative to the direction of buckling), the work done would be

$$-\tfrac{1}{2} \int_{-\frac{l}{2}}^{+\frac{l}{2}} M_{Yy} \frac{di}{dx} dx = -\tfrac{1}{2} \int_{-\frac{l}{2}}^{+\frac{l}{2}} M_{Yy} \frac{d^2y}{dx^2} dx = \pi M_{Yy} \frac{y_0}{l}.$$

* A. N. Procter, "The Solution of Buckling Problems by an Approximate Method," ENGINEERING, vol. 144, page 63 (1937).

The work done by a uniform transverse bending moment applied normal to the minor axis, causing the member to buckle laterally and also to twist, is the difference of the work done by the compressive and tensile forces induced in the member and is

$$\tfrac{1}{2} \int_{-\frac{l}{2}}^{+\frac{l}{2}} \frac{M_{Xx}}{a} \left(\frac{d(y + \frac{1}{2} a\theta)}{dx}\right)^2 dx - \tfrac{1}{2} \int_{-\frac{l}{2}}^{+\frac{l}{2}} \frac{M_{Xx}}{a} \left(\frac{d(y - \frac{1}{2} a\theta)}{dx}\right)^2 dx = \frac{\pi^2 M_{Xx} \theta_0 y_0}{2l}$$

where θ is the angle of twist at a point x from O and is assumed to be $\theta_0 \cos \frac{\pi x}{l}$ when θ_0 is the angle of twist at O, and a is the moment arm of the forces induced in the member by M_{Xx}. The work done by a uniform torque which produces an angle of twist θ_0 at mid-length is found to be $\frac{1}{2} M_{Tt} \theta_0$. The sum of the work done by the applied forces in deflecting the member laterally and twisting it is equal to the sum of the strain energy of flexure in terms of the flexural rigidity EI_Y and the strain energy of torsion in terms of the torsional rigidity GI_T, E and G being the modulii of elasticity in flexure and torsion, I_Y the moment of inertia in the direction of buckling and I_T the torsion constant of the section. Using the same form of deflection curve, the strain energy of flexure would be

$$\tfrac{1}{2} \int_{-\frac{l}{2}}^{+\frac{l}{2}} EI_Y \left(\frac{d^2y}{dx^2}\right)^2 dx = \frac{\pi^4 EI_Y y_0^2}{4l^3}$$

and the strain energy of torsion

$$\tfrac{1}{2} \int_{-\frac{l}{2}}^{+\frac{l}{2}} GI_T \left(\frac{d\theta}{dx}\right)^2 dx = \frac{\pi^2 GI_T \theta_0^2}{4l}.$$

* *loc. cit.*

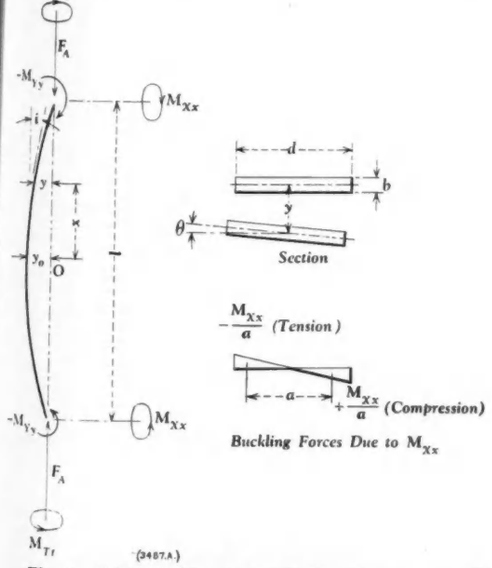


Fig. 1 Column with ends freely hinged.

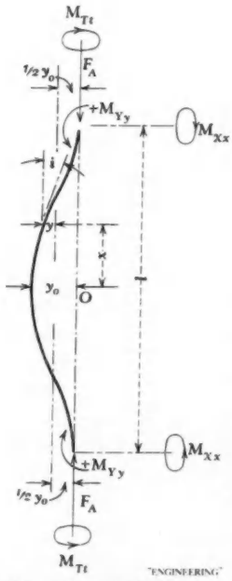


Fig. 2 Column with ends restrained.

Figs. 1 and 2 The total work done in flexure and torsion forces acting on structural members is equal to the sum of the strain energy in flexure and torsion. The critical value of one of the applied forces is found by ascertaining the conditions to give its lowest value.

When the deflection y_0 in the direction of buckling is small, the energy equation for an Euler member would be:—

$$\frac{\pi^2 F_A y_0^2}{4l} + \frac{\pi M_{Yy} y_0}{l} + \frac{\pi^2 M_{Xx} \theta_0 y_0}{2l} + \tfrac{1}{2} M_{Tt} \theta_0 = \frac{\pi^4 EI_Y y_0^2}{4l^3} + \frac{\pi^2 GI_T \theta_0^2}{4l}.$$

In order to determine the critical value of one of the applied forces, etc., the quantity in question should be separated and its minimum value found by differentiation.

COLUMNS UNDER COMBINED LOADING

To obtain the critical axial load of a column under the conditions assumed above, the energy equation should be put in the form:—

$$F_A = \frac{\pi^2 EI_y}{l^2} + \frac{GI_T \theta_0^2}{y_0^2} - \frac{4 M_{Yy}}{\pi y_0} - 2 M_{Xx} \frac{\theta_0}{y_0} - \frac{2 M_{Tt} l \theta_0}{\pi^2 y_0^2}.$$

Differentiating with respect to θ_0 and equating to zero:—

$$\frac{dF_A}{d\theta_0} = \frac{2 GI_T \theta_0}{y_0^2} - \frac{2 M_{Xx}}{y_0} - \frac{2 M_{Tt} l}{\pi^2 y_0^2} = 0.$$

Solving for θ_0 we have

$$\theta_0 = \frac{y_0 \left(M_{Xx} + \frac{M_{Tt} l}{\pi^2 y_0}\right)}{GI_T}. \quad . \quad (1)$$

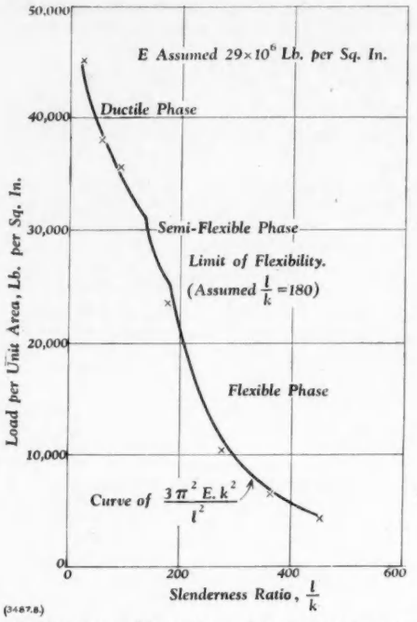
Substituting this value of θ_0 in the equation for F_A and putting $P_Y = \frac{\pi^2 EI_Y}{l^2}$ the critical axial load, F_A'', will be:—

$$F_A'' = P_Y - \frac{4 M_{Yy}}{\pi y_0} - \frac{\left(M_{Xx} + \frac{M_{Tt} l}{\pi^2 y_0}\right)^2}{GI_T}. \quad . \quad . \quad (2)$$

In order to evaluate the buckling force, F_A'', it is necessary either to eliminate y_0 in equation 2 or to substitute a suitable expression for it. For a long (Euler) column it is found that $y_0 = \gamma \frac{Z_y}{A} \frac{\rho^2}{\rho_0^2}$ gives good results, γ being a non-dimensional coefficient depending on the material, thickness and cross-sectional profile of the member, Z_y the section modulus about the axis of buckling, A the area of cross-section, ρ the slenderness ratio $\left(\frac{l}{k}\right)$, and ρ_0 the slenderness ratio of a member of the same cross-section at the Euler limit—this limit not being caused by ductility, local buckling or other such weakness. For medium-length members which, when axially loaded, are unable to sustain the Euler load, P_Y should be replaced by P_Y', which is the column strength beyond the Euler limit and y_0 may then be represented by $\gamma \frac{Z_y}{A}$. For a mild-steel rolled member of practical cross-section and ends freely hinged, ρ_0 is about $\frac{l}{k} = 95$ and γ is about 1·4. The value of ρ_0 and γ vary for different materials and cross-sections according to the elastic properties and the transverse distortion produced by the axial shear. ρ_0 is also dependent on the end conditions of the members.

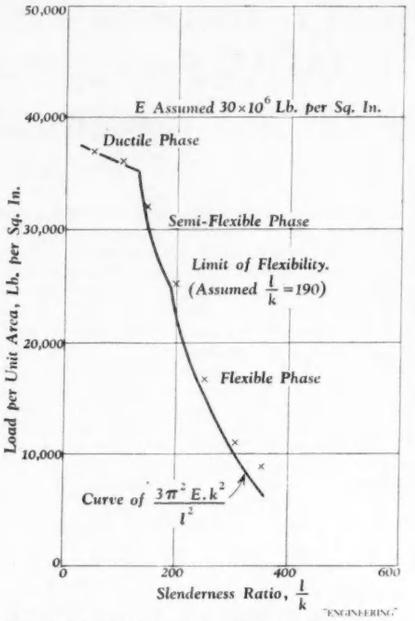
The member shown in Fig. 2 is similar to that considered above, but the ends are fully restrained by the end couples $+M_{Yy}$, so that the other applied forces, F_A, M_{Xx} and M_{Tt} cause it to buckle in double curvature ($\psi = 2$). The co-ordinate axis is taken through the points of contraflexure* and the co-ordinate y at a distance x from the origin, O, is assumed to be $\frac{1}{2} y_0 \cos \frac{2\pi x}{l}$, y_0 being the lateral deflection at O. Using the same method of calculation as before it is found that θ_0 has

* Dr. E. H. Salmon, *Materials and Structures*, vol. I, page 204, Fig. 167. Longman, Green and Co. Ltd., 1931.



(3487.8)

Buckling tests on 1 in. × 1 in. × ⅛ in. wrought-iron angles with ends fixed. Tested by J. Christie *Trans. Amer. Soc. C.E.*, vol. 13, page 103 (1884).



"ENGINEERING"

Tests on 3 in. × 3 in. × ½ in. mild-steel angles with ends flat. Tested by A. H. Strand and L. R. Strickenberg *Bureau of Stand.*, Tech. Paper No. 218, vol. 16, page 652 (1922).

Fig. 3 The diagrams illustrate the normal behaviour of axially loaded struts with the ends fully restrained. The flexible phase is the Euler phase as modified by the end fixing moments. The limit of flexibility is the Euler limit beyond which, although elastic, the struts are unable to carry the Euler load, because they are not sufficiently flexible. The ductile phase is caused by local inelastic shortening of the struts at points where the material is overstressed.

the same value as before (equation 1) and the critical axial load (F_A'') will now be:—

$$F_A'' = 4\,P_Y - \frac{2\,M_{Yy}}{\pi\,y_0} - \frac{\left(M_{Xx} + \frac{M_{Tt}\,l}{\pi^2\,y_0}\right)^2}{G\,I_T} \quad . \quad . \quad . \quad (2A)$$

When the couples $+ M_{Yy}$ are just sufficient to restrain the ends of the member it is clear from Fig. 2 that they would each be equal to $\frac{1}{2} F_A\,y_0$, so that, in the absence of M_{Xx} and M_{Tt}, equation 2A reduces to $F_A'' = 4\,P_Y - \frac{2\,(\frac{1}{2} F_A\,y_0)}{\pi\,y_0}$ and $F_A'' = 3{\cdot}03\,P_Y$. Professor Eaton Hodgkinson, after carrying out more than 200 tests (some in conjunction with Edwin Clark) on struts and columns up to 10 ft. long and of various materials, cross-sections and end conditions, came to the conclusion that the strength of a long column with the ends flat is 3·107 times the strength of a similar column with the ends round* and a number of other series of tests, such as those illustrated in Fig. 3, on long columns give similar results for ends flat and ends fixed. It is found, however, that when slender struts of small or thin section are tested with the ends fixed or flat†, they may fail at $F_A'' = 4\,P_Y$, so that there appear to be two critical conditions when the ends are fully restrained. In thin bars M_{Yy} might become zero when the load reaches $4\,P_Y$, or, alternatively, the deflection curve may then become changed in shape and in effect. This would follow from equation 2A. The limit of flexibility, ρ_0, of a member with ends fully restrained is twice that of a similar member with the ends freely hinged.

When the axial force, F_A, is not constant throughout the length of the member, a loading coefficient, α, may be used to qualify F_A'' in equation 2 or 2A. Considering a freely hinged member having an axial force of zero at the top end, increasing uniformly to F_A at the lower end, due, possibly, to it's own weight, the work done in causing a deflection, y_0, would be

$$\tfrac{1}{2}\int_0^{\frac{l}{2}} \tfrac{1}{2} F_A \left(1 - \frac{2x}{l}\right)\left(\frac{dy}{dx}\right)^2 dx + \tfrac{1}{2}\int_0^{\frac{l}{2}} \tfrac{1}{2} F_A \left(1 + \frac{2x}{l}\right)\left(\frac{dx}{dy}\right)^2 dx.$$

This is 0·55 multiplied by $\frac{\pi^2 F_A y^2_0}{4}$, the work done by a uniform force, F_A, so that for this kind of loading $\alpha = 0{\cdot}55$. When the ends of the member are fully restrained $\alpha = 0{\cdot}5$. Values of α for other variations of the axial loading may be estimated similarly.

* Phil. Trans. Roy. Soc., 1857, page 855. Also, Barlow, *Strength of Materials*, page 186. Crosby Lockwood and Co., 1867.

† R. E. Smith, *Column Tests on Some Proposed Aluminium Standard Structural Sections*. Research Report No. 28, pages 9 and 33. Aluminium Development Association, 1955.

SECONDARY BENDING UNDER COMBINED LOADING

The combined effect of a system of axial loads, bending moments and torques will produce greater deflections than the sum of the deflections due to the applied forces, etc., acting separately. The resultant effect of the combined action not only gives a reduced value of the buckling strength of the member, as indicated in equation 2 or 2A, but it also induces greater bending stresses in the member, so that the material may be overstressed before the buckling conditions are reached. It may, therefore, be sometimes necessary to estimate the maximum combined stresses under working loads. To do this the value of y_0 may be calculated from equation 2 or 2A, by substituting for F_A'', M_{Yy}, etc., the values of the maximum forces and moments which act simultaneously and then solve for y_0, or alternatively the formula may be solved for y_0, which, in the case of equation 2 is given as a footnote below columns two and three.

When, however, M_{Tt} is zero, this reduces to the simpler formula:—

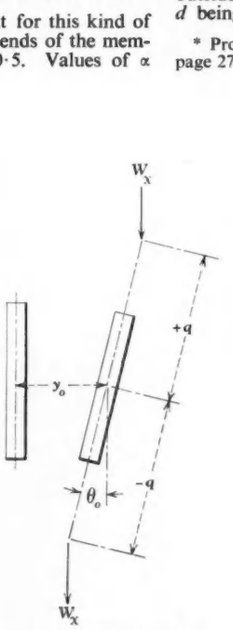
$$y_0 = \frac{\frac{4}{\pi} M_{Yy}}{\left(P_Y - F_A - \frac{M_{Xx}^2}{G\,I_T}\right)}$$

and when M_{Xx} is zero

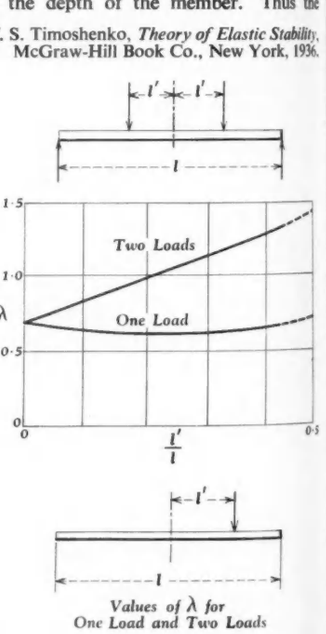
$$y_0 = \frac{\frac{4}{\pi} M_{Yy}}{(P_Y - F_A)}$$

which is a simple Perry type of formula for a laterally loaded strut, and when $- M_{Yy}$ is produced by the eccentric application of F_A, the formula would be $y_0 = \frac{4}{\pi} \frac{e\,F_A}{(P_Y - F_A)} l^2$. Should F_A be a tensile force it may be represented in this formula by $- F_A$, so that the deflection is given by $y_0 = - \frac{4}{\pi} \frac{e\,F_A}{(P_Y + F_A)}$. When y_0 has been calculated, θ_0 may be calculated from equation (1), so that the deflection of the outside edges of the members will be $y_0 = \frac{1}{2} d\theta_0$, d being the depth of the member. Thus the

* Prof. S. Timoshenko, *Theory of Elastic Stability*, page 27. McGraw-Hill Book Co., New York, 1936.



Section of Beam at Mid-Span



Values of λ for One Load and Two Loads

Fig. 4 Deep beam loaded above or below the centroid. The lateral thrust, induced by the force in the compression area, causes such a beam to buckle. The lateral restraint of the force in the tensile area causes the beam to twist, but this is modified by the transverse shearing forces and also by the application of the transverse loading to points above or below the centroid. The distribution of the loading along the beam introduces another variable factor, λ, as illustrated for two types of loading.

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"ENGINEERING"

Equation 2:—

$$y_0 = \frac{\left(\frac{4\,M_{Yy}}{\pi} - \frac{2\,M_{Xx}\,M_{Tt}\,l}{\pi^2\,G\,I_T}\right) \pm \sqrt{\left(\frac{4\,M_{Yy}}{\pi} - \frac{2\,M_{Xx}\,M_{Tt}\,l}{\pi^2\,G\,I_T}\right)^2 + 4\left(P_Y - F_A - \frac{M_{Xx}^2}{G\,I_T}\right)\frac{M_{Tt}^2\,l^2}{\pi^4\,G\,I_T}}}{2\left(P_Y - F_A - \frac{M_{Xx}^2}{G\,I_T}\right)}$$

secondary stress produced in the member due to the combined action of the applied forces would be $6\left(\frac{F_A}{A} - \frac{M_{xz}}{Z_z}\right)\frac{(y_0 \pm \frac{1}{2}d\theta_0)}{b}$, b being the breadth. The bending moment, M_{yy}, may not always be produced by end couples, but by the application of lateral forces to the member. This may be provided for by substituting a coefficient, β, of M_{yy} instead of $\frac{4}{\pi}$. The values of β for various types of loading may be estimated by methods similar to that used for estimating α in the previous paragraph. For example, if the lateral load is applied at mid-length, $\beta = 0{\cdot}82$ with ends freely supported, and $0{\cdot}2$ with ends fully restrained, M_{yy} being the maximum free bending moment applied. β may also be calculated from the standard formulae for the deflections of laterally loaded columns; e.g. with a lateral load, W_Y, applied at the mid-length, $y_0 = \frac{W_Y}{48\,E\,I_Y}\left(\frac{P_Y}{P_Y - F_A}\right)$*. Substituting $\frac{P^2}{E\,I_Y} = \frac{\pi^2}{P_Y}$ and $W_Y\,P = 4\,M_Y\,y$, $y_0 = \frac{0{\cdot}82\,M_y}{(P_Y - F_A)}$, so that $\beta = 0{\cdot}82$.

BEAMS UNDER COMBINED LOADING

To estimate the critical transverse bending moment, M_{xz}'', required to buckle a laterally unsupported, deep beam, equation (2) is solved for M_{xz}, giving

$$M_{xz}'' = \sqrt{G\,I_T\left(P_Y - F_A - \frac{4\,M_{yy}}{\pi\,y_0}\right)} - \frac{M_{Tt}\,l}{\pi^2\,y_0} \quad . \quad . \quad . \quad (3)$$

The bending moment is here considered to be uniform, but when it is produced by transverse loading, it is necessary to use a coefficient, λ, of M_{xz}'' to provide for the effect of the variation of the bending moment along the span, also for the torque produced by the transverse shearing forces. Thus, in a simply supported beam carrying a central point load, W_X, applied at the centroid the work done by the compressive and tensile forces in the beam, $\frac{M_{xz}}{a}$, to produce a lateral deflection, y_0, and an angle of twist, θ_0, at mid-span is

$$\tfrac{1}{2}\int_{-\frac{l}{2}}^{+\frac{l}{2}} \frac{M_{xz}}{a}\left(1 - \frac{2x}{l}\right)\left(\frac{d(y + \frac{1}{2}a\,\theta)}{dx}\right)^2 dx$$

$$- \tfrac{1}{2}\int_{-\frac{l}{2}}^{+\frac{l}{2}} \frac{M_{xz}}{a}\left(1 - \frac{2x}{l}\right)\left(\frac{d(y - \frac{1}{2}a\,\theta)}{dx}\right)^2 dx$$

$$= 0{\cdot}35\left(\frac{\pi^2\,M_{xz}\,\theta_0\,y_0}{2\,l}\right)$$

M_{xz} being the maximum bending moment at mid-span. The coefficient $0{\cdot}35$ is the value of α for this distribution of forces along the beam. The lateral deflection of the beam will cause a lateral displacement of W_X which will induce a torque, $W_X\,y_0$, so that the work done in torsion will be $\frac{1}{2}W_X\,y_0\,\theta_0$ and, since $W_X = \frac{4\,M_{xz}}{l}$, this is equal to $\frac{2\,M_{xz}\,y_0\,\theta_0}{l}$ which may be written $\frac{4}{\pi^2}\left(\frac{\pi^2\,M_{xz}\,\theta_0\,y_0}{2\,l}\right)$. Thus the total work done is $\left(0{\cdot}35 + \frac{4}{\pi^2}\right)\frac{(\pi^2\,M_{xz}\,\theta_0\,y_0)}{2}$ and the approximate value of λ is $0{\cdot}35 + 0{\cdot}41 = 0{\cdot}76$, a more accurate value being $0{\cdot}74$ with ends freely supported laterally and $0{\cdot}87$ with ends fully restrained laterally (but freely supported transversely). When, however, the transverse loading is applied above the centroid of the beam, the torque caused by the lateral displacement of the load is increased, thus reducing the critical bending moment, M_{xz}'', and when it is applied below the centroid the torque is reduced and

* Salmon, loc. cit., page 233.

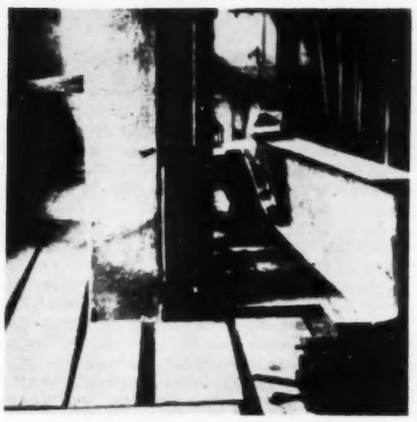

Fig. 5 The buckling of beams was investigated by Sir William Fairbairn, but the first comprehensive series of tests on the buckling of deep beams was carried out by Edgar Marburg on Bethlehem Sections up to 30 in. deep. The illustration shows a typical torsional failure of a beam of ductile material ; the beam was a 15 in. by 5½ in. × 42 lb. per ft. American I-section. (E. Marburg, *Proc. American Soc. Test Mat.*, 1909, page 403.)

M_{xz}'' is increased by an amount which may be estimated from equation (3). Taking again as an example a simply supported beam carrying a point load, W_X, at mid-span, but applied a distance q above the centroid, q being small compared with l, and F_A also M_{yy} being zero, equation (3) becomes

$$\lambda\,M_{xz}'' = \sqrt{G\,I_T\,P_Y} - \frac{M_{Tt}\,l}{\pi^2\,y_0} \quad . \quad (3A)$$

When buckling occurs, $M_{Tt} = W_X\,q\,\theta_0$, and since q is small compared with l, M_{Tt} is small compared with M_{xz}, so that from formula (1) $\theta_0 = \frac{y_0\,\lambda\,M_{xz}}{G\,I_T}$ approximately, and $M_{Tt} = \frac{W_X\,q\,y_0\,\lambda\,M_{xz}}{G\,I_T}$. Thus the last term of formula 3A becomes $-\frac{W_X\,q\,l\,\lambda\,M_{xz}}{\pi^2\,G\,I_T}$ and since $W_X\,l = 4\,M_{xz}$ this is $\frac{4\,q\,\lambda\,M_{xz}^2}{\pi^2\,G\,I_T}$. But since M_{Tt} is small compared with M_{xz}, $\lambda\,M_{xz}^2 = \frac{G\,I_T\,P_Y}{\lambda}$ approximately, so that the term becomes $\frac{4\,q\,P_Y}{\pi^2\,\lambda}$ and

$$\lambda\,M_{xz}'' = \sqrt{G\,I_T\,P_Y} - \frac{4\,q\,P_Y}{\pi^2\,\lambda} \quad . \quad (3B)$$

When the load is applied a distance q below the centroid the minus sign changes to plus and it is found that the formula gives good results for slender beams under both conditions. (Reference should also be made to Dr. J. Prescott, *Applied Elasticity*, Art. 305 (1924).) Fig. 4 shows a diagrammatic section of a deep beam loaded as above also values of λ for various positions of a point load and of two symmetrically applied loads. Fig. 5 shows an American 15 in. by 5½ in. I-beam failing by torsional buckling under top flange loading; this was one of a series of tests conducted by Edgar Marburg and reported in the *Proceedings* of the American Society for Testing Materials for 1909.

WATER RESEARCH

Expanding Service for Manufacturers and Distributors

The Water Research Association is a late comer among the large number of research associations, each concerned with the interests of some particular industry or activity. Its youth is indicated by the fact that its first annual report, covering the period from July 1, 1955, to June 30, 1956, has just been issued. This is able to record promising progress as it states that the membership has grown from 10 in 1953 to 170 in 1956. Water undertakings vary greatly in size, and the total membership is not a direct measure of the water handled. At the date of the report 57 per cent. of the water distributed in Great Britain and Northern Ireland came from members of the Association. The list of members indicates that a number of large and important authorities have not joined; it may be anticipated that the second annual report will show that most of them have done so. The problems with which the Association is concerned are of interest to manufacturers as well as distributors and the membership of commercial firms, now standing at two, may be expected to increase.

It is the practice of the Department of Scientific and Industrial Research to assist research associations with financial grants conditional on adequate support being given by the industry, on their activity, and on the presentation of an approved programme of research. The Water Research Association at the time of the report was not in receipt of such financial assistance, but an application was to be made in due course. Such additional funds if provided would enable the Association to extend the range of its activities and, presumably, to increase its staff. Among the work at present in hand is an investigation on underground leakage. It has been asserted that if the losses by leakage from old and defective mains could be eliminated the supplies available to consumers would be increased by one-third. The Water Research Association does not commit itself to this statement, but the question of the detection of underground leakage occupies an important section of the report. This begins with the statement that " it was felt that the deliberate contamination of water flowing in a pipe with a chemical, radioactive or otherwise, should not be considered as a basis for detection." There are two other methods of detection, one depending on the noise made by the leak and the other on temperature changes in the ground surrounding the leak. The first of these has been investigated and particulars of 30 commercially available leak-detection instruments have been collected. In general, the instruments comprise a vibration pick-up, a three or four valve amplifier and a visual, or aural, indicator; in one instrument the normal electronic valve is replaced by a transistor. Considerable differences were found between the performances of individual instruments, and it was decided that these were due to variation of the acoustic characteristics of the coupling between the pick-up used and the ground surface. Work is accordingly proceeding on this particular aspect of the problem.

Another subject under investigation concerns the use of non-metallic materials of construction, and information has been collected about Continental and American experience in the use of plastics for the construction of service pipes and mains. An important aspect of this subject concerns the possibility of water carried by a polythene service pipe becoming tainted with gas if the service pipe is laid in proximity to a leaking gas main. It is stated that " the plastics industry confirms that polythene cannot be rendered impervious to coal gas or any other gas," and it has accordingly been decided, after experimental work, to draw up a code of practice giving instructions about the installation of such pipes. The minimum distance from a gas supply, which will be allowable, will probably depend upon the type of soil in which it is laid. The Research Division of the Association is concerned with acquiring a scientific background on the techniques and problems of water purification. An investigation on the mechanism of coagulation, and the use of coagulation aids, is to be carried out.

Book Reviews

PRODUCING THIN FILMS

Vacuum Deposition of Thin Films. By L. HOLLAND. *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (70*s.*)

A substance evaporates because some of its constituent molecules, in the course of random motion near a free surface, succeed in passing through that surface into the space beyond. What happens to them then depends on their new environment, and it is well known that the rate of evaporation is increased if the escaping molecules are rapidly removed, for example by air currents, from proximity with the parent substance. Conversely, evaporation is impeded if molecules of vapour accumulate close to the escape surface. Under such conditions, or even if a gas is present, many of the newly evaporated molecules collide with other molecules before they can move very far in the direction of their escape velocity. If, however, evaporation takes place into a high vacuum, the free path of the emitted molecules is so markedly increased that a large proportion of them can impinge, before colliding with another molecule, on any surface interposed across their direction of travel.

Another factor of importance in promoting evaporation is the temperature of the evaporating substance. The higher the temperature, the greater is the speed at which the molecules composing a substance are moving, and therefore the greater is the chance that molecules near the free surface will be able to pass through and far enough beyond it to escape altogether. This result is greatly enhanced if the substance is in the liquid, rather than in the solid, phase. Metals that are solid at room temperature must, therefore, be maintained molten by continuous heating if they are to evaporate at significant rates. When such heating is carried out in a very high vacuum the evaporation consists of radiating atoms or molecules at high temperature which, if they impinge on a surface specially prepared to be perfectly clean, condense and adhere, often very tenaciously, in the form of a thin metallic film.

Such, briefly and over-simplified, is the physical basis of the deposition of thin solid films by vacuum evaporation. A process that produces somewhat similar resultant films, by slow disintegration of the cathode electrode during an electric glow discharge in a gas at low pressure, is more complex and less completely understood although the phenomenon of cathodic sputtering, as it is called, was observed over a century ago. It is a matter of experimental fact, however, that under bombardment by positively-ionised molecules of the rarefied gas, material leaves the electrode surface, either as free atoms or as molecules formed by chemical combination with the gas; and that some of these liberated particles can be condensed on surfaces exposed to the cathode. Attempts to explain the separation of atoms or molecules from an electrode invoke the concept, either of thermal evaporation due to high temperature in areas of molecular dimensions subject to impinging ions, or a more direct transfer of energy from the gas ions to surface molecules of the cathode material.

Vacuum evaporation and sputtering are, thus, two different processes, one demanding controlled heating, the other a high voltage glow discharge. The films they produce also display significant differences of detail. But they have, in common, the need for very high vacua, itself a specialised technology with which the firm of Edwards High Vacuum, Limited, is closely associated in this country. Mr. Holland, the author of the book under review, is head of the Edwards Vacuum Coating Research Laboratory where, with an enviable range of experimental facilities at his command, he is in an almost unique position to test the validity of theories, verify physical data, confirm established procedures and develop improvements made possible by advances in high-vacuum equipment.

During the past ten years sputtered metal films have been superseded for many purposes by vacuum evaporated films, and Mr. Holland has consequently devoted the major part of his book to the latter form of deposition. He deals, in turn, with high vacuum apparatus and the techniques of using it for the deposition of metallic films and with methods of cleaning substrate surfaces, and of keeping the evaporating low-pressure atmosphere free from contaminants that may be derived from any of the substances within the apparatus. He goes on to discuss the peculiarities of the metals to be evaporated, the methods employed for heating them to vaporising temperatures, and the interactions that take place between the metallic-vapour particles and the residual gas in the evacuated deposition chamber. Next follows a sequence of chapters devoted to techniques that have been found successful for depositing films of various metals and alloys, and for preparing films having the special properties needed for electrical and optical purposes. For the often less exacting requirements of industrial films, corresponding techniques are discussed, with emphasis on the problems encountered in the metallisation of plastics and paper.

The later chapters of Mr. Holland's book are concerned with the basic physics, techniques and applications of cathode sputtering, in which subjects he has assembled a very great amount of information specifically intended to be of use in the practical preparation of films for a variety of technical purposes. At present the most widely used sputtered films are composed of metallic oxides, so it is to be expected that, after a sufficient account of the essential features of laboratory apparatus and commercial plants, he describes with a wealth of detail the special techniques for producing metallic oxide films and the respective properties that make such films valuable for optical, electrical and metallurgical research.

Two outstanding impressions conveyed by an inevitably imperfect examination of Mr. Holland's book are the comprehensive study that has been undertaken to make him an undisputed authority on his subject, and the formidable volume of experimental work that he has himself carried out. He has consequently been able, in his book, not only to survey practically every relevant published paper of any importance—he cites a bibliography of 557 references—but also to criticise constructively the work of others, to include a good deal of new and original information, and to arrive, in the light of his personal researches and experience, at convincing conclusions on many controversial questions. At a time when the scientific and industrial applications of vacuum deposited films are rapidly advancing in quality as well as extending in quantity, a text of this character, admirably illustrated, and well documented and indexed is assured of a cordial reception among all classes of workers in this particular field.

WANTED AND UNWANTED VIBRATIONS

Fundamentals of Vibration Analysis. By N. O. MYKLESTAD. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (6.50 dols.); *and McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (49*s.*)

Vibrations, set up when a sudden impulse or a sustained periodic force is applied to a mechanical structure possessing mass and stiffness or properties equivalent thereto, are a matter of ever-present concern to the engineer. Sometimes the object may be to design a system capable of performing vibrations of a specified type; at other times the vibrations may be unwanted and then steps have to be taken to suppress them or to localise their influence. Neither is likely to be successfully accomplished unless it is based on a thorough understanding of vibration theory.

In applying mathematical analysis to the study of vibrations it is desirable to begin with the simple harmonic vibration, which represents the simplest type of vibration that can be exhibited by a system with lumped mass and stiffness parameters. Provided the differential equations are linear or, to a first approximation, may be treated as such, any more complex type of vibration can, in virtue of Fourier's theorem, be regarded as resulting from the superposition of a set of simple harmonic vibrations, the frequencies of which are integral multiples of a certain fundamental frequency. Moreover the analysis can be extended to include vibrations affected by damping and systems in which the mass and stiffness parameters are distributed either uniformly or non-uniformly.

This fundamental logical approach is adopted in the present text, which is confined to the classical methods of analysis and has not been extended to cover non-linear vibrations. Undamped free vibrations of systems the configuration of which can be specified in terms of a single co-ordinate are considered first. Linear, angular, torsional and flexural vibrations of this type are investigated in turn, together with the forced vibrations resulting from the application of an external periodic force and vibration initiated by suddenly applied forces. Energy considerations and the Rayleigh method are developed, and a section is devoted to the critical speeds of shafts and static balancing. Free and forced vibrations of single degree of freedom systems with viscous damping are considered next. It is shown that a suitable selection of dimensionless parameters (frequency ratio, damping and amplification factors) enables curves capable of representing the behaviour of any such system to be drawn, and the usefulness of vector diagrams is pointed out. The principles underlying the action of vibration measuring instruments for determining relative displacements, velocities and accelerations, and of frequency measuring instruments are discussed, while other sections are devoted to the important practical problem of vibration isolation, power consumption in vibrating systems and the initial transient vibrations which are often of considerable importance. The effect of non-viscous (solid friction) damping on free and forced vibrations of single degree of freedom systems, often treated somewhat cursorily, is very clearly explained.

The remainder of the book is concerned with the more complicated systems that result from the interconnection of two or more single degree of freedom systems. These coupled systems are characterised by normal modes of vibration equal in number to the degrees of freedom of the composite system, though their frequencies differ from the natural frequencies of the individual component systems vibrating independently. The general vibration of such a system results from the superposition of the various normal modes in varying proportions. While the analysis is usually straightforward, the algebra tends to become heavy and often unmanageable, particularly when damping is taken into consideration, unless the variables chosen are normal, or principal, co-ordinates. An alternative method of approach involves the use of influence coefficients. A more powerful line of attack is based on the use of generalised co-ordinates and forces and Lagrange's equations. Examples of all these are given and certain problems, such as the double pendulum, are treated by more than one method either in

the text or in one of the numerous sets of examples. It is often possible to pass from a system with n degrees of freedom to a continuous system, as from the string of beads to the uniform string, by making n tend to infinity. In many instances the solution is most readily derived by operational calculus methods, though these are not introduced. The problem of balancing is intimately connected with that of vibration and a most informative account is given of equipment designed for the dynamical balancing of rigid rotors. The concluding chapter is devoted to tabular methods of finding natural frequencies for longitudinal and torsional vibrations of crankshafts and for bending vibration modes of propellers, turbine blades and aeroplane wings.

In this work Dr. Myklestad presents the fundamentals of classical vibration analysis in an exceptionally clear and thorough manner, and at the same time incorporates a number of novel features relating to orthogonality conditions, damped modes of vibration, vibration instruments and balancing.

★ ★ ★

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Information Theory and Its Engineering Applications. By D. A. BELL. Second edition. *Sir Isaac Pitman and Sons, Limited*, 39 *Parker-street, London, W.C.*2. (25*s.*)

Information theory, underlying as it does all exchange of information, is of special importance in telecommunications and automatic control systems. In the second edition, the chapter on "Coding" has been enlarged, a chapter on "Decoding" added, and other material brought up to date. The historical background is given throughout.

Radio. Vol. III. By JOHN D. TUCKER and DONALD F. WILKINSON. *English Universities Press, Limited*, 102 *Newgate-street, London, E.C.*1. (12*s.* 6*d.*)

The third volume of the series has been written to cover the syllabus of the City and Guilds of London Institute, Radio 3 examination. It also follows closely the syllabus of the Higher National Certificate (A.1). The subject matter includes amplifiers, oscillators, transmitters and transmission, receivers, and picture transmission. There are test questions at the end of each chapter.

The Economic Use of Industrial Fuel Oils. By J. T. B. BOOKEY. Reprinted from "The Steam Engineer." *John D. Troup, Limited*, 90 *High Holborn, London, W.C.*1. (6*s.*)

In order to make the best use of imported fuel oil the author describes such points as the availability of fuel oil, its commercial evaluation and the properties of the different types. He then goes on to consider question of storage and handling, types of oil burners, and practical combustion considerations. Charts and nomograms are included for calculating various quantities.

Zirconium: Its Production and Properties. Prepared by the Staff of the Northwest Electrodevelopment Laboratory, Bureau of Mines, under the direction of STEPHEN M. SHELTON. U.S. Bureau of Mines Bulletin 561. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (1 dol.)

Much of the experience gained in the large-scale production of low-hafnium zirconium during the years 1947 to 1954, at the electrodevelopment laboratory at Albany, is embodied in the present technical report. The chapters, each of which has been contributed by a recognised authority in the specialised field covered, deal with zirconium ores, reduction processes, the magnesium-reduction process, melting, properties, fabrication, alloys, uses of zirconium metal, availability and cost of ductile zirconium, and analytical procedures. The illustrations, both half-tone and line, number 138.

Induction Heating Practice. By D. WARBURTON-BROWN. *Odhams Press, Limited*, 96 *Long Acre, London, W.C.*2. (21*s.*)

This book constitutes a detailed study of the high-frequency induction heating process and deals with its practical application to industrial problems. It is addressed to the production engineer or executive officer interested in the possibilities of installing, or extending, induction-heating equipment, to the foreman or operative working with, or adapting, this type of equipment, and to all others concerned with heat treatment in engineering production.

Marketing

NEW CONCEPTS OF MARKETING

One of the vice-presidents of Ford Motor Company, Detroit, said recently: "Selling is more than a salesman's job" and proceeded to tell how the American motor industry of 1956 are beginning to realise that selling is but part of marketing, and that marketing is a science involving such things as highly specialised and detailed research and analysis. The Chrysler Corporation have recently instituted a centralised marketing organisation which is to co-ordinate and direct all merchandising from a central office, instead of leaving it to the separate divisions. Before this re-organisation Chrysler, who in 1953 accounted for over one-fifth of the total car production in the United States, did no sales analysis, no market research, no sales planning. The return of competition forced their share down to 13 per cent. in 1954 and it is unlikely to be higher than 16 per cent. this year. The central marketing organisation is expected to plan and lead a recovery.

Chrysler are not alone in placing the emphasis on central sales planning and in enlisting to their aid the theories and techniques of marketing as taught in the American universities. Ford have a vice-president for marketing, not sales. Mercury's "general marketing department" has a marketing analysis and planning manager on the same level as the sales manager. In this country two large groups of engineering companies have recently centralised sales under a commercial director. The marketing concept is gaining ground,

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Product Planning

"The design function—gap or bridge between sales and production?" was the descriptive title of a paper read by the joint managing director of Morphy-Richards Limited, Mr. R. W. Morphy, to the national conference of the British Institute of Management earlier this month. Mr. Morphy described an attempt by his company to co-ordinate their design policy, which was made with the help of industrial consultants. A product-planning section was set up "to co-ordinate the work of the separate departments concerned from inception until the product is finally marketed and serviced."

The progress of a product was divided into 26 stages, printed on a "history card," which provides date columns for progressing. Meetings are called to consider the results of completed stages and to agree the remaining programme. Basic to this procedure, which is described briefly in the following note, is the establishment of a set of principles which govern design policy. Mr. Morphy considered at some length the different approaches: of the artist, who seeks to make the design look attractive, and of the engineer whose purpose in life is to make the design work. The production man is often left to execute conflicting and often extravagant aims. But in Mr. Morphy's view production—"the proper application of the manufacturing crafts," among which he includes the processes employed in mass-production—should provide inspiration and make its full contribution to design. Function, construction and appearance, in that order, have all to be considered.

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A Procedure for Design

Mr. Morphy did not comment on the functions of sales in the co-ordination of design, but he has clearly in mind the important part which sales must play in the formulation of any successful design policy. At the initiation meeting of the product-planning committee, the idea for a new product is considered "from the angles of sales policy." Preliminary investigations will include "some degree of market research, selection and testing of competitive products, perhaps some laboratory exploration, and usually a patent search." A specification meeting is held to agree a specification to which the development department can produce, in turn, a provisional design, working models, drawings and a rough estimate of the cost. These are reviewed at a provisional design meeting, when drawings are issued for consideration by the production buying, inspection and service departments. Sales approval is required for the prototypes, which follow, and an assessment of servicing problems and spares requirements is made by the service department. A tooling release meeting is then held, when the final drawings are issued and orders placed for tooling. Market research plays a vital part in assessing the scale on which production is to be planned.

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Analysis of Distribution Costs

A plea to introduce more method in the analysis of the cost of distribution was made at the B.I.M. conference by Mr. G. A. Edwards, managing director of S. C. Johnson and Sons, Limited, the wax and polish manufacturers. Most of the problems he mentions are encountered daily in the engineering industries. In all industries the head of the firm is liable to be told that the sales force should be expanded, that direct selling is costing too much, a sales area is doing badly, that discounts should be increased or a design modified, and much more besides. All these assertions call for decisions. Yet their validity is rarely established. In fact, few firms have any reliable information on the effect of various aspects of their sales activities in relation to their cost. As Mr. Edwards says, controls over sales costs "are in their infancy compared with those normally exercised over the production and manufacturing costs."

The aim of any cost-control system must be to attack waste, and the following are the main approaches into which such a system can be divided: reduce the number of products marketed, cut out dead sizes and varieties, relate sales objectives to the potential of sales areas, define the responsibilities of salesmen specifically, and train sales personnel to use cost data.

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Tackling the New World

"In 1955 and 1956 we carried out extensive market research in America and satisfied ourselves that there was a vast potential for the sale of our equipment there, although the market was highly competitive." A subsidiary company was set up in Los Angeles, a leading firm of advertising consultants were engaged and a series of lectures organised to put over the technical skills and installation "know-how" at their disposal. The company concerned, Colt Ventilation Limited, of Surbiton, Surrey, are no industrial giant, but a live and aggressive concern specialising in the solution of industrial ventilation problems.

The interest of this venture is its precept: that the belief that a British advisory service, set up in this country for manufacturers and architects, "cannot be matched anywhere in the States." One reason, of course, could be that U.S. firms cannot afford to be very lavish in services which involve expensive staff. On the other hand, it could be that the Americans have become so imbued with the "packaged" or "standard" types of "do-it-yourself" kits that they have left a gap where skill and experience is required to solve difficult problems peculiar to each case. The enterprise of Colt Ventilation is well conceived and deserves to succeed in a market where our needs to sell are greatest and the most urgent.

The main hall at the Hydraulic Research Station, Wallingford. In the foreground is the Eyemouth Harbour model. Immediately behind the Eyemouth model are models of, on the left, the river Trent, and on the right the river Karnafuli (Pakistan).

LOOSE-BOUNDARY HYDRAULICS

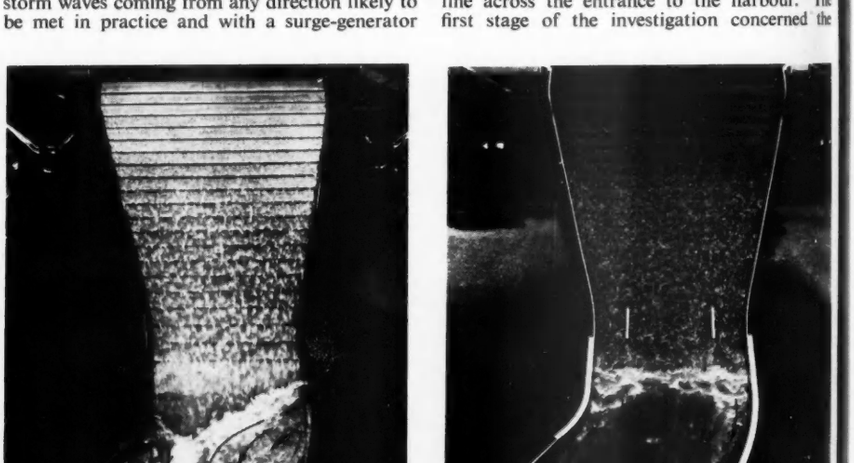
IMPROVING DESIGNS FOR HARBOUR AND RIVER WORKS

The first part of establishing the Hydraulics Research Station at Wallingford, on the River Thames, in Berkshire, is now complete. The main hall—the scene across the floor of hall as it is to-day is to be seen in the illustration above—is in full use. The floor area is 300 ft. long by 200 ft. and is clear of obstructions save for the two columns supporting the roof. Provision has been made, and the space is available, for the hall to be extended by the addition of bays on three sides of the existing building. Altogether the station is favoured by possession of a 70 acre estate, with the administrative divisions in the house and with ample grounds for laying out more buildings and establishing more experimental facilities as opportunity, and money, permits.

Although some fundamental work on river flow problems is being undertaken, the bulk of the current work is directed towards the solution of *ad hoc* problems, such as the flooding or silting of a specific river or the erosion of a particular stretch of East Anglian coast, by the use of mobile-bed models. This work is aided by the Station's well-equipped workshop and an instrument division which has already designed some excellent instruments, especially their miniature propeller current meters and the free-running flow meters; other instruments developed there include a bed-level plotter, for tracing the undulations across the bottom of a model; and a wave recorder for determining the heights of the waves, possibly only an inch or so high, generated in harbour models. Some descriptions of the models which are at present being operated are given below together with some observations on their purpose and the type of results being obtained. It may be emphasised that, with the present state of hydraulic knowledge, the model approach provides the surest and the most, if not the only, rational method of design in certain circumstances. Apart from work in India, the techniques of mobile-bed models is almost a wholly British development.

Among the outdoor models at Wallingford is one of the new harbour now under construction at Tema, Gold Coast, West Africa. The model reproduces a stretch of coast 13,000 ft. long and extends the equivalent of 7,000 ft. out to sea. It is equipped with the means of producing storm waves coming from any direction likely to be met in practice and with a surge-generator capable of causing waves, much longer than storm waves, having a period of anything between 40 seconds and 5 minutes. These latter waves, although even in nature only a few inches in height, can cause considerable horizontal movement of ships, and to investigate the navigating problems due to currents two radio-controlled model ships are being operated.

The general plan, as proposed by the consulting engineers, required a breakwater, about 4,000 ft. long and running parallel to the coast-line across the entrance to the harbour. The first stage of the investigation concerned the



The Navet Dam spillway model. The left-hand illustration shows the final design (but without the deflector walls) running under flood-discharge conditions, with extensive turbulent flow and much of the flow concentrated in only part of the channel. The right-hand illustration shows the vast improvement effected by the two simple deflectors proposed by the Laboratory.

efficacy of this breakwater and showed that it could be shortened by about 500 ft. without reducing the efficiency of the harbour. With the cost of constructing the breakwater at the extreme end being between £200 and £300 per foot, the model has more than justified its existence. In the second stage of the investigation, nine different designs of the entrance to a small adjacent fishing harbour have been examined. Many advantages are claimed for the entrance layout finally evolved, as compared with that originally proposed, but as the entrance is located at a depth where the waves naturally break, it has been found impracticable to obtain an entirely satisfactory design for all directions of the tide.

An adjacent model, also in the open, represents a typical stretch of the East Anglian coast and is being used to investigate why some beaches erode and why, on others, the sand piles up, and to assess the value of different forms of sea-defence structure, such as sea-walls, groynes and breakwaters. The model has recently been used to examine the influence of a permeable screen consisting of a line of spaced piles set parallel to the shore; such a screen was found to have a small beneficial effect if it was located along a line between high and low water. One system of groynes that has been designed was found to reduce the volume of sand travelling along the beach to about a quarter of the normal rate. The behaviour with other types of orthodox groynes is now being investigated.

IMPROVEMENTS TO SMALL HARBOURS

Eyemouth harbour, situated in a rocky bay nine miles north of Berwick-on-Tweed, is principally a fishing port, about 50 fishing boats using it as their base. At certain times a ridge of sand, or sandbar, forms in the entrance channel to the harbour as a result of wave action, so that the boats can enter and leave the port only near high water and this is having a serious effect on the fishing trade. Several proposals have been put forward to remedy this situation, including a sluicing scheme in which tidal water impounded in Eye-Water at high water would be released at low water to scour the entrance clear of sand by the impetus of its velocity. A design for a new harbour entrance, which might cost £250,000, has also been prepared.

The Station has been asked by the Scottish Home Department and the Eyemouth Harbour Trusts to find why the sandbar forms, to test the effectiveness of the various proposals suggested to prevent its formation and to advise on the most economical solution to the problem. The conditions leading to the formation and growth of the sandbar have been examined by survey teams from the Station working in Eyemouth Bay and much useful information has been obtained.

The model, which has recently been constructed at the Station, and is to be seen in the foreground of the illustration opposite, will be used to compare the various proposals for harbour improvement. The bed of the bay and the beach in the model has been made of fine sand from Leighton Buzzard in Bedfordshire. It is planned that in the proving of the Eyemouth harbour model use will be made of radioactive tracers in the form of soda-glass particles activated at Harwell. This is the first time they have been used in this way at the Station.

SPILLWAY DESIGN

Another example in which the Station, by a model investigation, has been able to propose improvements to a design concerns the spillway to the Navet Dam. The Navet River, in Trinidad, is to be dammed at a point about four miles below its source, the reservoir so formed providing a water supply for the surrounding area. Flood water, in excess of storage requirements, will be returned to the old river course downstream of the dam, by means of a spillway. The design of the spillway involved a departure from standard practice due to the topography and the need to build as cheaply as possible. The proposed spillway consisted of a 200 ft. weir which discharged water down a sloping channel to the stilling basin, where much energy of the water is dissipated. (The model investigation showed the loss of energy to be as much as 60 per cent.) From this stilling basin the water flowed over a second weir to a second stilling basin and then to a erodible earthen flood channel leading back to the old river channel.

In the model, shown in the two illustrations at the foot of page 660, part of the reservoir was reproduced so that the approach conditions to the 200 ft. weir would be correctly simulated. At the downstream end of the model the first 300 ft. of the flood channel was moulded in sand in order to study bed and side erosion. The three changes to the design which were suggested are as follows. Firstly, it was shown that the proposed depth of the upstream stilling basin was insufficient to cause stilling for the higher range of discharges. The bed level of the basin was, therefore, lowered by the equivalent of 3 ft. This proved to be effective and the hydraulic jump was formed in its correct position at the upstream end of the basin. Secondly, a large eddy which formed in the curved stilling basin was eliminated by placing comparatively small deflector walls in the fast flowing water near the foot of the stepped channel. Thirdly, information was obtained concerning the design of the lower fall and the protection of the erodible bed of the flood channel, making it possible to predict the level to which the bed of the flood channel would erode and the original design was modified to suit these conditions. A model test indicated that if this modification was incorporated bed material would tend to build up against the downstream end of the structure, thus ensuring its safety.

RIVER MODELS

Among the river models being studied, or subjects for future work, may be enumerated those of the Karnafuli river in East Pakistan, and, at home, of the Mersey estuary, the river Trent and the Severn near Shrewsbury. At Shrewsbury, the river floods whenever the flow exceeds 10,600 cusecs, and a model investigation, now complete, has been undertaken from which it has been possible to determine that it was only necessary to improve (by dredging and other training works) 3 miles of the river, not 7 miles as contained in the projected flood-relief scheme, and that there existed a now dry channel, which may well have been an earlier course of the river, that could be used as a by-pass channel.

The Karnafuli river flows into the north-eastern corner of the Bay of Bengal; some ten miles from the sea, on the right bank, lies the port of Chittagong which, since partition from India in 1947, has been and is being developed as the major port for East Pakistan. The model study is aimed at solving problems which have arisen at the port and in the adjacent river approaches, and is being carried out for the Government of Pakistan under the Colombo Plan. The model has vertical and horizontal scales of $\frac{1}{60}$ and $\frac{1}{3600}$, and a time scale of 1/64·5.

The problems are to establish and maintain a channel of adequate depth alongside new jetties by suitable river training, avoiding dredging; to stabilise the channel upstream where at present it meanders, a predominant factor in the stability of the jetty channel; and to establish and maintain adequate depths in all parts of the approaches to the port from the sea. In addition, the effects on the river and port of a substantial hydro-electric project, now under construction 40 miles upstream of Chittagong, will be studied. The reservoir created by this scheme will reduce the freshwater floods, will trap the sediment carried down from the headwaters and will maintain a dry weather flow.

The Karnafuli is a typical monsoon fed river, its freshwater discharge ranging from a maximum in the wet season which may be as high as 250,000 cusecs to a minimum in the dry season of 2,000 to 3,000 cusecs. The highest tides have a range of 18 ft. at the entrance to the river. The model represents some 20 miles of the Karnafuli and is being built in two stages. Stage I (now in operation) starts about 10 miles upstream of Chittagong and finishes some 3 miles from the sea, and will be used to solve the first two problems above. Stage II, which will be built later, will extend to the sea and will include a stretch of coastal water about 5 miles long and 2 miles wide.

The Snowy Mountains Scheme—4

ELECTRICITY DISTRIBUTION IN SOUTH-EAST AUSTRALIA

FUTURE TRANSMISSION AT 330 KV

The Snowy Mountains scheme* has made practicable the inter-connection of the State electricity systems of N.S.W. and Victoria. The power stations of the scheme are in an area about 250 miles from both Sydney and Melbourne, and the power to be transmitted is such that a voltage of 330kV will prove the most economical. A network at this voltage will gradually be extended over N.S.W. and Victoria to act as a backbone to the existing transmission lines. The Snowy Mountains scheme has made this supergrid a practical possibility many years before it could otherwise have been justified.

NETWORKS IN N.S.W. AND VICTORIA

The main electrical problems have been: to chose a suitable transmission voltage; to establish principles for the operation of the group of hydro-electric stations; to feed the gradually increasing output of the power stations into the existing networks without spending too much on capital works too soon; and to overcome construction difficulties in restricted or precipitous areas in the mountains.

The siting of generating plant depends on the economics of generation and distances between suitable sites and the main load centres. In N.S.W. and Victoria about half the population live in the capital cities, Sydney and Melbourne, and outside the capitals the population is thinly spread. As a result, power stations have been built in or near the capital cities, and transmission remote from the cities is relatively poor.

N.S.W. has large bituminous-coal deposits within a 100 mile radius of Sydney; in fact Sydney sits on top of an immense saucer of coal, which outcrops at varying distances from the city. Newcastle in the north, Wallerawang to the west, and Wollongong to the south are all convenient sources of coal. In the past most of Sydney's demand for electricity has been met by coal-fired stations in or near the city. The small country demand has been met by local stations or transmission at voltages of 66 or 132 kV.

Since the second World War the load both in the country and in the capital has greatly increased. The policy now is to build power stations on the coalfields—for example, Talla-

* The three previous articles on the Snowy Mountains Scheme were published in the issues of August 24 (page 232), September 28 (page 394) and November 16 (page 630). This fourth article is the last in the series.

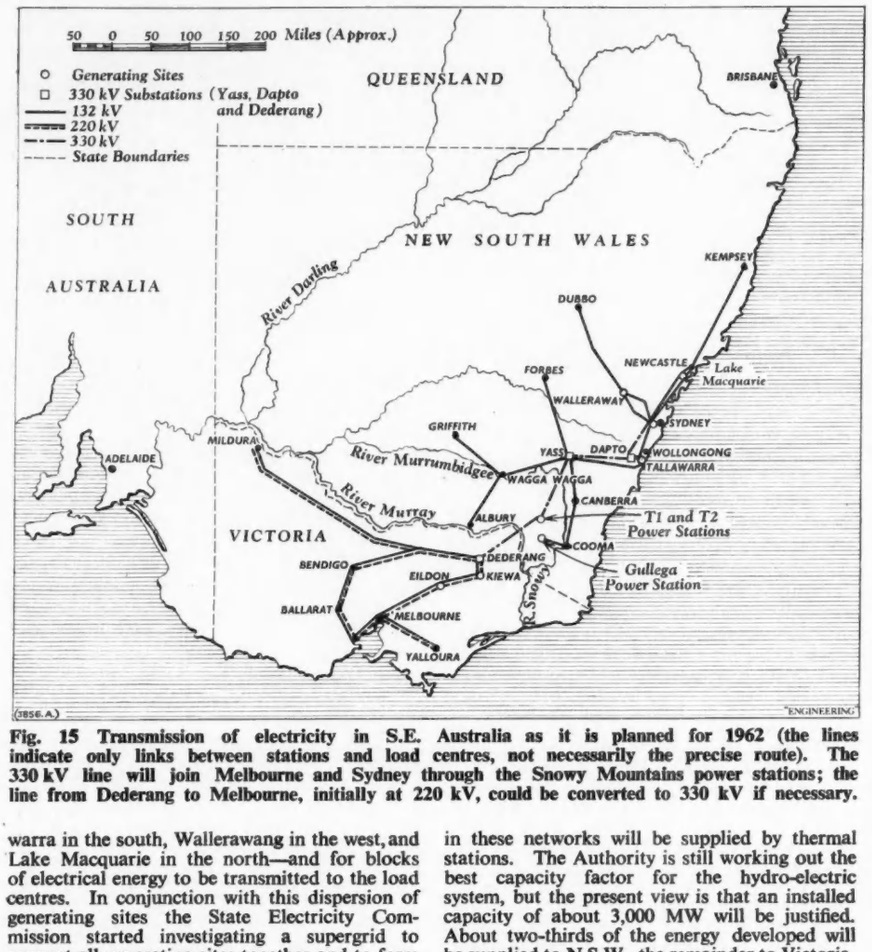


Fig. 15 Transmission of electricity in S.E. Australia as it is planned for 1962 (the lines indicate only links between stations and load centres, not necessarily the precise route). The 330 kV line will join Melbourne and Sydney through the Snowy Mountains power stations; the line from Dederang to Melbourne, initially at 220 kV, could be converted to 330 kV if necessary.

warra in the south, Wallerawang in the west, and Lake Macquarie in the north—and for blocks of electrical energy to be transmitted to the load centres. In conjunction with this dispersion of generating sites the State Electricity Commission started investigating a supergrid to connect all generating sites together and to form a backbone to the existing 132 kV system.

In Victoria most of the base load has been supplied from a power station on the rich brown-coal deposits at Yallourn, 80 miles east of Melbourne. Other loads were met by peak load thermal stations and minor hydro-electric schemes. When the details of the Kiewa hydro-electric scheme (300 MW, 160 miles from Melbourne) were being fixed in 1946, a transmission voltage of 220 kV was chosen. The first circuit from Kiewa went into service in 1955. The same voltage was chosen to transmit another block of power (350–400 MW) from new thermal stations at Yallourn, and the first two 220 kV circuits from there will go into service this year. There are several other rich brown-coalfields in the Latrobe valley, about 100 miles east of Melbourne, and over the next 15 to 30 years it is probable that 3,000 MW of power will be exported from there to Melbourne.

Fig. 15 shows the transmission lines that will probably exist in S.E. Australia in 1962. The 330 kV line to Dederang could be extended to Melbourne if the amount of power to be sent from the Snowy Mountains stations, Kiewa, and Eildon justified the change from 220 kV to 330 kV for the Dederang-Melbourne section. At both Sydney and Melbourne, the power would be fed into a city ring, not direct to the city as shown in Fig. 15.

CHOICE OF TRANSMISSION VOLTAGE

The amount of electrical energy to be dispatched from the Snowy Mountains area when all planned power stations are built can be estimated quite closely. At the time of writing it appears that there will be 15 power stations with a total annual production of 5,830 million kWh. The capacity factor of the stations will be lower than the system load factors of the N.S.W. and Victoria networks, and base loads in these networks will be supplied by thermal stations. The Authority is still working out the best capacity factor for the hydro-electric system, but the present view is that an installed capacity of about 3,000 MW will be justified. About two-thirds of the energy developed will be supplied to N.S.W., the remainder to Victoria.

The amounts of energy to be transmitted and the distances involved in both hydro-electric and thermal developments pointed to the need for an EHV transmission system. The State systems in N.S.W. and Victoria were also at the stage where they could be connected to form an integrated network for south-east Australia, if it could be economically justified. The voltage chosen for the supergrid had to be one that would transmit the power economically, and tie in with the two State systems. The use of the same voltage to collect power from the stations in the Snowy Mountains was also considered. A suitable range of voltage was from 275 to 380 kV. Both 275 and 380 kV are proposed standard voltages of the International Electrotechnical Commission, and at first it was thought that one of these two should have been chosen. However, analysis showed that for the amount of energy to be transmitted the least cost, making allowances for both running and capital charges, was for a voltage of about 330 kV.

Further, if 380 kV had been used, the step in relation to the N.S.W. voltage of 132 kV would have been too great; on the other hand, had 275 kV been used it would have been unsuitable for inter-connection with the Victorian system at 220 kV. A voltage of 330 kV was therefore the best for the various jobs that had to be done. It was also found that this voltage could be used for collecting power from the stations in the Snowy Mountains.

To establish how many lines would be needed to carry safely the load at different stages of the development, the stability limit per line for varying voltages was worked out. Transmission stability is a function of a number of parameters, among which are: type of fault, duration of fault, automatic reclosing, reactance of sending and receiving end systems, inertia constants of generators, number of intermediate switching stations, and series capacitors. Using varying values of these parameters, studies were made firstly by longhand calculation, secondly on the alternating-current network analyser of the Electricity Commission of Victoria, and lastly on the micro-network analyser of the Electricité de France.

Single-circuit transmission towers will be used to transmit the load from the Snowy Mountains to both N.S.W. and Victoria. Although double-

Fig. 16 330 kV transmission towers; the upper diagram shows how they will be strung for initial operation at 132 kV.

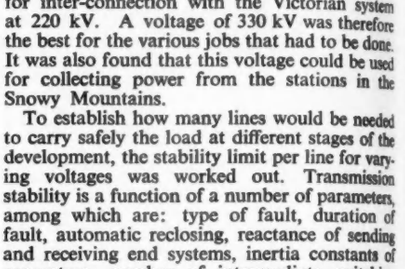


Fig. 17 The collecting system in the Snowy Mountains area is still subject to variation, as the legend shows. T1 and T2 will have a joint switching station about half way between the two stations and out of the Tumut valley.

circuit lines are more economical, the single-circuit lines were preferred because they suit better the gradual development of the load, are more convenient for maintenance, and are more reliable.

TRANSMISSION TOWERS FOR 132 AND 330 KV

The towers to be used are of the type shown in Fig. 16, and will withstand the breakage of both twin conductors of the centre phase. If an outer phase breaks the cross arm breaks at such a load that the tower is no more heavily loaded than when the centre phase breaks. By this "light" construction the cost of two single-circuit lines is made about equal to the cost of a double-circuit line of sufficiently heavy design to withstand breakage of any phase. However, for altitudes from 3,000 to 5,200 ft., where ice forms and strong winds blow, the single-circuit towers will be built so that they will not fall if any phase breaks. The conductors are 54/0·117 in. aluminium and 7/0·117 in. steel, two such conductors to each phase; the equivalent copper cross-section per phase is 0·71 sq. in.

Fig. 16 also shows how the towers on the Yass-Dapto sector will be strung when they are first used. This part of the line, which is now under construction, will be run as a double-circuit 132 kV line. The two circuits will transmit power from the Tallawarra power station to Yass and the south west of N.S.W. When T1 power station is commissioned its output will be fed at 330 kV to Yass and transformed down to 132 kV. When it becomes necessary, the towers from Yass to Dapto will be converted to their design working at 330 kV.

POWER STATION INTERCONNECTION

The power stations of the Snowy Mountains scheme are well scattered, as Fig. 2 in the first article on the scheme shows (ENGINEERING, page 232, August 24, last). The collecting system must be able to carry large blocks of power to switching stations for dispatch to N.S.W. and Victoria. One method of collection that was discussed in the early stages was to use a voltage lower than the main transmission voltage of 330 kV, probably 132 or 220 kV. This was found to be uneconomical because of the increase in losses and the reduction in stability caused by double transformation.

The present proposal is to use 330 kV to collect power in the Snowy Mountains area. The only exceptions will be the groups of smaller stations whose output will be transmitted by short 132 kV lines to the nearest switchyard of a major power station. Output will be transformed more economically in this way. Fig. 17 shows the present plans. One 132 kV line exists, and three 330 kV lines are definitely planned. The remainder are still under consideration, and electrical or geographical difficulties may mean that the plan shown will be altered.

The T1 and T2 power stations will have a common switching station. They are close together, and the very limited space at the bottom of the precipitous Tumut valley would make separate switchyards close to the stations very difficult to build. The eventual control system will probably extend the group control—as in the case of T1 and T2—to other groups, such as M4, M5L, M5H and M6, and M1A, M1B, M2H, M2L, and M3, as shown in Fig. 17. When the scheme is complete there may also be one overriding control, where representatives of the state networks of N.S.W. and Victoria will liaise with the Authority's dispatching controllers.

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Designed to assist in the essential business of re-training the railway man for Diesel operation, the Shell-Mex and B.P. film "The Diesel on Rail" brings out the need for cleanliness in handling fuel and lubricating oil. The damage which dirt can cause to the fuel pump is dramatically shown. The film runs for 26 minutes and can be borrowed by application to Shell-Mex House, Strand, W.C.2. It is available in both 16 and 35 mm. versions.

FIRES IN INDUSTRY

MINIMISING RISKS TO MEN AND MATERIALS

Problems concerning the best means of coping with industrial fires and of minimising their serious human and economic losses have engaged the attention of industrialists for as long as industry has existed, and have led to the formation of many efficient fire-fighting services and to much research. Nevertheless, losses of life and property from this cause have continued at a very high level. In view of the urgency of this question, and the magnitude of the risks to men and materials involved in such occurrences, the British Occupational Hygiene Society decided that its sixth conference should be devoted to a general investigation of the subject.

In all, five papers were presented for discussion at the meeting, which was held at the London School of Hygiene and Tropical Medicine, on November 12 last. In his opening address to the delegates, Sir George Barnett, H.M. Chief Inspector of Factories, said that, including indirect penalties due to falls in production, the sacrifice of future business, and losses of employment, the cost of industrial fires was very high indeed.

Serious occurrences were due to the uncontrolled spreading of fires which could have been dealt with initially, before the conflagrations developed. Broadly speaking, the cause of any fire was some aspect of human behaviour which it was difficult to check by rules and regulations. Legislation was mainly directed to restricting the spread of fires and to ensuring the safety of workpeople.

An important principle of safety was the separation of escape routes from process rooms. Stairways should not be open to the rooms they served, but should be protected by self-closing fireproof doors. Open stairways were liable to hinder escapes and to encourage the spreading of fires. Vertical spreading was also promoted by the existence of open hoistways and these should be prohibited. The prevention and control of the initial outbreak were primarily matters of individual responsibility, training and discipline, and these raised problems which were fundamentally difficult.

HOW FIRES START

The author of the first paper to be discussed, Mr. N. C. Strother Smith, A.M.I.E.E., was then introduced by the President-elect of the Society, Dr. P. Pringle, chief medical officer to the Central Electricity Authority, who also acted as chairman of the conference. In his paper, entitled "A Technical Survey of Fires in Industry," Mr. Smith, who is director of the Fire Protection Association, said that statistical analyses had shown the existence of some fifty different causes of fires. In brief, the prevention of outbreaks resolved itself into the separation of all potential sources of ignition from ignitable materials.

The most common source of ignition was some form of heating equipment, and blow lamps, cutting and welding gear, and smokers' materials, in particular, were the cause of many fires. Overheated electric cables, electric sparks, and sparks or heat from mechanical friction were other causes encountered from time to time. Prolonged heating at temperatures down to 150 deg. F. could cause the charring of cellulose materials. Convection heaters could become too hot if the free access of air was impeded by stacking or draping materials near them. Friction in bearings and conveyor belts was common, and sparks caused by foreign objects getting into machinery had been known to ignite textiles being processed.

The full proceedings of this conference are expected to be available shortly. Copies may be obtained, price 10s. 6d. *post free, from these offices. Orders, accompanied by remittances, should be addressed to the Publisher,* 35 *and* 36 *Bedford-street, London, W.C.2.*

The fire risk associated with a substance depended on its physical properties. In solids, when the density, specific heat and thermal conductivity were all low, ignition was facilitated. Vapour density, vapour pressure and flash point governed the ignition of liquids. Proximity to the source was a factor with solids, but not necessarily so in the case of liquids, because the vapour was mobile. Gases were subject to concentration limits between which explosion was possible, and density was also important. The risk from dusts arose both in deposits and in air-borne clouds. Chemicals which released oxygen were particularly hazardous and it was necessray to keep a careful watch for possible causes of spontaneous combustion, especially in the case of stored materials.

Fires were spread by the release of hot gases and the formation of combustible gases from heated organic substances, which might flash when oxygen was admitted, such as by the breaking of a window. Good conductors, like metal beams, might also cause a fire to spread if they were directly heated by flames. Burning liquids could flow under doors and down shafts, and explosions raised dust and might rupture vessels containing other incendiary materials. Indirect encouragement for fires to spread was given by poisonous gases and fumes which impeded fire fighting.

Whenever possible fire-separating walls and floors should be used to assist in confining possible outbreaks. Staircases, lift shafts, conveyor openings and ventilating ducts provided means for fires to spread. Fire records showed that the blame for most fires rested on the shoulders of industrial managements. The failure to maintain machinery properly, to inspect vessels used for inflammable liquids, and to study and supervise possible hazards indicated a lack of understanding on the part of managements as to how fires developed. Vital safeguards for the lives of occupants of buildings were provided by the adoption of the principles of fire-resisting construction, together with careful management and housekeeping; delaying the growth of a fire gave time for workers to escape by the normal routes.

FIRE SERVICES IN ACTION

The next paper to be discussed was "Industrial Fires from the Point of View of the Fire Service," by Mr. E. R. Ashill, A.M.I.F.E., chief officer of the Croydon Fire Brigade. The author said that the number of industrial fires was increasing, in spite of there not having been a corresponding rise in the number of fatal and non-fatal accidents. No less than half the estimated fire losses for 1955 were due to fewer than 300 of the total of some 100,000 fires attended by fire brigades in Great Britain.

The organisation of fire brigades had been considerably improved since the war and it was very unusual for inadequacy of personnel or equipment to be encountered when fighting industrial fires. Arrangements for mutual assistance between fire brigades, efficient salvage operations, and the dissemination of technical information had all contributed to solving the problems set by the increasing number of fires. In order to achieve a reduction in the number of industrial fires, it was necessary for the principles of fire prevention to be generally recognised and applied. More concern was required on the part of managements and more care on the part of the workpeople. In all these matters, the fire protection officers of the various fire services were very willing to give advice.

Building construction was closely related to fire risks, since a fire could be confined within a reasonable area by imperforate walls and ceilings which had a suitable degree of fire resistance. Whenever possible, large floor areas should be subdivided. The opening up of walls for piping and the use of flimsy doors was to be

deprecated. It was unfortunate that industry tended to require premises with massive undivided areas for manufacturing and storage purposes. The maximum size of a single compartment in a building should not exceed 250,000 cub. ft., but double that area was allowable in cases where automatic sprinklers were installed. Where building boards were used as linings for ceilings, or for similar purposes, they should be of a type having a high degree of fire resistance.

The Factories Act, 1937, required provisions to be made for the escape of the occupants of buildings in case of fire, but it was not sufficiently realised that only about one-half of the industrial premises in the country had been inspected and certified. Fire-warning systems were also required by the Act. Another point made by Mr. Ashill was that fire drill was of great value in checking the effectiveness of precautions and should not be neglected. Moreover, the detection of fires should not be left to the night watchman; in many cases, he was found asleep by the fire brigade when they arrived, and some firms even provided him with a bed. Automatic detection devices were costly but they earned insurance rebates, and their installation was often imposed as a condition by local authorities for permission to erect new premises.

The success of fire fighting operations was more probable when information about the lay-out of premises, processes worked therein and the nature of materials stored, was on record at the local fire service headquarters, along with the location of water supplies, gas cocks and electric switches. It was quite common for access to water to be impeded at night, when nobody was about. Dangerous roofs, also, should be clearly indicated, so that the firemen could avoid using them. Unprotected openings in floors were a danger, especially to fire fighters working in dense smoke.

PUTTING FIRES OUT

The afternoon session was opened with a paper by Mr. P. Nash, of the Fire Research Station, on " Fire: Its Detection and Extinction." He quoted figures showing that a reduction in fire losses could best be achieved by studying the reasons why large fires occurred, and by improving and disseminating knowledge on how best to handle fires in their early stages.

Most large fires, he said, were well developed when discovered; the peak periods for the receipt of warnings were from midnight to 4 a.m., and from 6 to 6.30 p.m. An automatic fire detection system could give notice of such outbreaks long before they had become large enough to attract attention. Heat sensitive detectors, operating in various ways, were tested by the Joint Fire Research Organisation in a special hot-air wind tunnel, in which rises in temperature and gas velocities observed in the initial stages of a fire could be reproduced. This enabled the sensitivity of alarms to be gauged and the correct setting of any adjustment necessary on them to be efficiently estimated.

Sprinkler systems not only detected fires but actively fought them with water sprays pending the arrival of the fire brigade. Although not suited to all types of risk, they had a very good record, and it was recognised that many fires would have become large but for the action of sprinkler apparatus. Smoke sensitive detectors were available which could give the earliest possible warning in many cases, since smoke was usually given off in detectable quantities before appreciable heat was produced. In choosing a detector the possibility that normal ambient conditions might set it off had, of course, to be borne in mind.

Water was not only the cheapest material, but it also possessed excellent properties for fire fighting. Experiments showed that 12 gal. would extinguish fires of 1,500 cub. ft. in extent, all the water being vaporised in the process. Extinction in these cases seemed to be due to the replacement of air by steam. A spray of water was better than a jet and easier to use. Water was used to prevent the spread of fires by radiation and it had been found better to coat the receiving surface by spraying water on to it rather than to use a curtain of water drops as a radiation shield.

Water was also used as a foam, especially for fires of liquid fuels. Important properties of a foam were its expansion, stiffness and drainage rate. Dry, powdered sodium bicarbonate and common salt were good against liquid fires, though there might be a temporary increase of the intensity of radiation which would be dangerous to life. The powders were effective only during application, so it was necessary to make sure that extinction was complete before stopping. Their effect was related to the surface area of powder applied per second. Powders sometimes caused foam to break down, when these substances were used together, owing to the presence of a metallic stearate surface coating on the powder particles for promoting easy flow.

Many tests of vaporising liquids for fire extinguishers had been carried out; chlorobromomethane was very efficient and fluorohydrocarbons were promising. Flat and fan-shaped sprays were best. A floating detector and Chlorobromomethane sprayhead had been developed for use in tanks of inflammable liquids.

HELP FOR THE INJURED

A paper on " First-Aid for Casualties from Fire " was then read by Mr. D. McG. Jackson, M.D., F.R.C.S., surgeon-in-charge of the Industrial Injuries and Burns Research Unit of the Birmingham Accident Hospital. He emphasised that the danger from burns was that the blood capillaries leaked plasma, roughly in proportion to the area burnt, and serious plasma loss added to skin injury produced shock, kidney damage and sometimes death, owing to there remaining an insufficient volume of blood in circulation. Furthermore, a burn was an open wound which could not be closed by sutures, like a laceration, and, therefore, it was peculiarly liable to infection.

Time was the most important consideration in the first-aid treatment of burns. Permanent damage from shock, no longer reversible by transfusion, might result within a few hours of an accident. Immediate transfer to hospital, accompanied by rest and drinks, was essential. Little treatment of a first-aid character could be given; the best that could be done was to reassure the victim that urgent arrangements were under way to get him to hospital. Severe burns were often painless, so sedatives were not required. Pain from small burns could be relieved by bathing in cold tap water.

The only local treatment for a thermal burn was to cover it with a sterile cloth to prevent infection; ointments or lotions should not be applied. Neither should blisters be broken nor dead skin removed. Chemical burns required immediate washing with plenty of water. Action of this kind was extremely urgent and a delay of seconds might have serious consequences. Burns of the respiratory system might be associated with poisoning by carbon monoxide or fumes. This condition was most serious and needed immediate hospital treatment.

In organising the transport of burn cases to hospital, it should be remembered that patients could travel 20 to 30 miles without resuscitation immediately after injury better than they could on the following day. The seriousness of a burn depended very much upon whether the skin was destroyed throughout a part of its depth only, or whether the total thickness was burnt. The former healed rapidly but the latter, when more than an inch or so in diameter, might take weeks to heal unless grafted, and would leave permanent scarring.

When delay in getting burned men to hospital was inevitable, plasma transfusion on the site, or during transit in the ambulance, might be necessary to control shock. Ideally, transfusion should be done within four hours of an accident, but, as a rule, the nearest hospital was the best place for action of that nature.

ACTION BY MANAGEMENTS

In the final paper, on " Managerial Responsibilities and Fire Prevention," Mr. H. Mason Bibby, M.Eng., M.I.Mech.E., of J. Bibby and Son, Liverpool, referred to risks due to the storage of organic or carbon-containing materials in bulk. There were well-established codes of practice for the safe storage of coal, whereby the ratio of surface to bulk and the provision of adequate ventilation, restricted the access of oxygen on the one hand, and prevented too great a rise in temperature by spontaneous combustion on the other. Some power stations stored their coal under water, not only to eliminate the fire risk, but also to avoid waste due to oxidation and the evaporation of volatile constituents.

Fires of palm kernels had occurred at various ports, particularly when the kernels were stored in sacks. These kernels contained about 45 per cent. of a readily oxidisable oil which was exuded on to the sacks when damage occurred in handling. The coarse materials of which the sacks were made then brought about a very effective exposure of the oil to oxidation, while piling of the sacks on top of one another restricted the access of cooling air, with a resultant rapid rise in temperature.

The responsibility of managements towards ensuring good storage and tidiness included the taking of positive measures in connection with the building, and of so arranging the premises as to enable cleanliness to become a natural habit The division of premises into cells offering but little change for the intercommunication of dust and vapours was of the greatest assistance. A special risk was associated with high-speed machinery, especially disintegrators which could generate sparks hot enough to ignite the material being handled. Flushing with plenty of air was a safeguard, but the possible consequences of blockages should always be borne in mind. Separators for the ground material were another potential danger, because the airborne concentrations would at some time pass through the values at which ignition was most likely. In such circumstances, a violent explosion might take place, and separators should always be isolated with full provision for ventilation to the outside atmosphere.

Repair and maintenance work on complex, modern plant was dangerous because it was often impossible to remove each unit to a safe place for attention. Again, time schedules might not allow for sufficient cleaning and draining to be effected before welding was started. In one large, continuous process shop, without fire breaks, the devastating possibilities of such circumstances had been demonstrated quite recently. Magnesium swarf was a dangerous material and attempts to extinguish fires from this source with water could release hydrogen. Most plastics were inflammable and were a source of considerable danger, especially when handled by small processing firms unaware of the fire risks involved.

Attention had to be given, also, to preventing small fires from becoming conflagrations. In the absence of automatic equipment, the provision of able-bodied, well-trained patrolmen was essential. The elderly night watchman, sleeping in a hut, was useless. Fire resistance should be anticipated in designing buildings so that they would resist collapse for long enough to enable a fire to be dealt with before it became extensive. Advice on such matters, and on other precautions, was readily available from the Fire Protection Association.

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A machine has been designed by Abtus, Limited, Vandon Court, Petty France, London, S.W.1, for drilling holes in rails to accommodate track circuit bonds. It consists of a 1¼ h.p. four-stroke J.A.P. engine the speed of which is controlled by a pre-set governor and which drives twin spindles. The drills fitted to these spindles are capable of drilling two holes of $\frac{3}{32}$ in. or $\frac{3}{8}$ in. in diameter simultaneously through the web of a 95 lb. bull-headed rail or a 109 lb. flat-bottomed rail in under 20 seconds. The machine can be quickly fitted, without clamping, to, or removed from, any size of rail.

Fig. 1 (left) Assembly line for shell sections on casters at Renfrew Works of Babcock and Wilcox, Ltd. Heat-exchanger sections for the Calder Hall and Annan Cross stations are fabricated in the works and welded together on site.

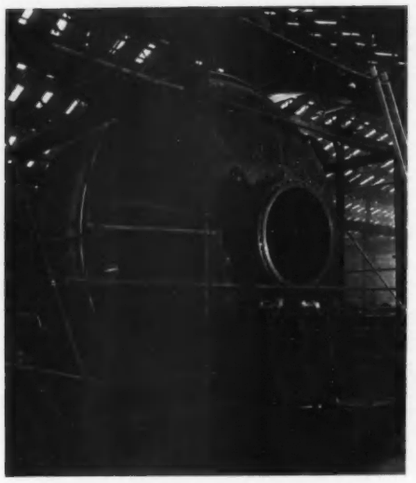

Fig. 2 (right) Domed head of heat exchanger showing the flanged connection for the gas inlet duct. The complete shells are 80 ft. high and weigh nearly 180 tons.

PRELUDE TO ATOMIC POWER

RESEARCH AND DEVELOPMENT SET THE STAGE

It is well known that the Calder Hall plutonium plant and power station was designed to make use of existing engineering processes as far as possible, with the result that capital costs are high and efficiency comparatively low. Since then the development of materials and techniques specially adapted to nuclear installations has proceeded rapidly, so that competitive nuclear power is now in sight. Speaking at a recent meeting of the International Bank, Sir John Cockcroft stated that the gross electrical power output of the first commercial nuclear stations for the Central Electricity Authority is likely to exceed that of Calder Works by a factor of three, with little increase in capital cost. Thus, instead of 92 MW, the new stations are likely to approach 300 MW in capacity. A fraction of this improvement must arise from the changed emphasis from plutonium to power production, but the major part is due to the extensive research that has been carried out, not only by the Atomic Energy Authority, but also by private companies within the four existing atomic energy groups. These groups tendered on October 1 for the first two C.E.A. stations at Bradwell and Berkeley. One company that has recently revealed some of the work it has been doing is Babcock and Wilcox, Limited, who for atomic energy projects are associated with the English Electric Company, Limited, and Taylor Woodrow, Limited. Babcock and Wilcox played a major part in the Calder Hall station, but it should be pointed out that their plans are by no means restricted to the gas-cooled reactor—witness the contract to build the reactor vessel for the Canadian NPD pressurised-water plant (page 635 last week) and the third paragraph in this week's Atomic Review. An account of the company's current atomic energy work appears in this article.

Babcock and Wilcox have already completed the manufacture at Renfrew of all the heat exchangers for the Calder Hall "A" and "B" stations and are at present engaged in the construction of corresponding items for similar stations at Chapel Cross, near Annan in Scotland. An assembly line for heat-exchanger shell sections, 17 ft. 6 in. in diameter, can be seen in Fig. 1, and Fig. 2 shows the domed head of a heat exchanger with a welder working near the flanged connection for the gas inlet duct. These heat exchangers have been fully described in ENGINEERING in recent articles on Calder Hall (pages 418, 469, 502, 534 and 563 *ante*). To cope with atomic energy requirements the company have built new tube and manifold shops involving an expenditure of more than £700,000, and it is thought that nuclear plant will eventually become a major item in the total output of the company.

So far Babcock and Wilcox have been concerned in this field largely with heat exchangers, in which heat is transferred from the reactor coolant gas to water for steam raising; now, however, they are equipping themselves to undertake pressure-vessel construction, the design and development of fuel elements, and the manufacture of fuel-handling equipment. The formation of an Atomic Energy Department, under the direction of Mr. W. F. C. Schaap, with Mr. T. B. Webb as manager, Mr. W. R. Wootton as assistant manager and Dr. W. B. Carlson as chief research engineer was recently announced in ENGINEERING (August 24, page 254). The department is based in London, where much of the design and project work is taking place. In 1957 the company is to install a Ferranti Pegasus electronic computer at its new head office at 209, Euston-road, London, N.W.1.

LARGER PRESSURE VESSELS

The output of a reactor can be improved by increasing its size, by use of higher operating temperatures, and by raising the coolant-gas pressure. These factors are discussed further in Atomic Review on page 669, in the paragraph which is headed "Reactor Output." It follows that the strength of pressure vessel at fairly elevated temperatures is of first importance since both size and gas pressure depend upon it. One approach is to increase the thickness, but since pressure vessels, like heat exchangers, are too large to be carried to site complete, some welding on site is necessary and this imposes a limitation. Vessels 2 in. thick are used at Calder Hall, but it is thought that the C.E.A. vessels are likely to be of the order of 3 in. in thickness. Engineers at Babcock and Wilcox believe that the welding of vessels 5 in. thick and more on site is well within possibility, but they do not intend to do so in this context—at least in the immediate future. Their approach is rather a combination of some increase in thickness with the use of improved steels. For the Canadian reactor vessel, which has an austenitic lining, Colvilles' Ducol W30 steel, with a tensile range of 34 to 42 tons per sq. in., is employed (see page 635, *ante*), but this will contain heavy water at 1,200 lb. per sq. in. and not gas at 150 lb. per sq. in. Babcock and Wilcox are working with the steelmakers to improve the characteristics of available steels still further, though it is possible that for the initial C.E.A. stations 28 tons per sq. in. boiler plate will be used by all groups. To ensure the high reliability necessary for these applications, a procedure has been adopted by which a half-scale vessel is tested to destruction; subsequently a part version of a full-scale vessel is similarly tested. Weld examination can be carried out with the aid of a 2 MV X-ray plant made by General Electric of America, which is suitable for use with plate up to 10 in. thick.

STEEL PLATE AND STUD TUBES

The construction of the Calder Hall and Chapel Cross heat exchangers has already been described elsewhere, but there are some further

Fig. 3 Finished heat-exchanger section with aerofoil studs. These sections are tested hydraulically. Some are also evacuated and tested for leakage electronically in a hydrogen atmosphere.

Fig. 4 Detail of studded tube construction for heat-exchanger element as tested in a boiler heat-transfer rig. The studs are resistance welded on to the tubes by semi-automatic machines.

Fig. 5 External tube connections to the heat exchangers are made by way of thermal sleeves which are welded on to the shells. Here the welds are shown being tested by means of halogen gas and an ionising detector.

resistance welded tube. A finished heat-exchanger element is illustrated in Fig. 3. Special aerofoil studs cut to length from elliptical-section strip on an automatic machine are welded on to the tubes by a battery of machines which are also partly automatic in operation; fully automatic versions are under consideration. The number and arrangement of the studs vary according to the particular heat-exchanger sections for which they are destined. The superheater sections are made from plain tubes with no studding. Nearly 11 million studs are required for each of the 32 towers for Calder Hall and Chapel Cross, making a total of 340 million. It is apparent therefore that in planning nuclear power stations the problem of rapid and efficient production of extended surface is of major importance. A close-up view of a studded tube appears in Fig. 4. The walls of the tubes are comparatively thin and may be bent cold with the studding protected by a special shoe. Future nuclear plants may, however, operate at higher pressures and require thicker tube and hence hot bending. Every section is tested hydraulically before dispatch and a proportion by insertion in a hydrogen atmosphere. The tubes are evacuated and any hydrogen leaking in is detected electronically. At first all tube sections were tested in this way, but no leaks were found and a sampling procedure is now used.

TESTING THERMAL SLEEVES

In previous articles we have referred to the thermal sleeves which may be seen on the outside of the heat-exchanger shells. To these the heat-exchanger tube connections are welded on site, and they are designed so that any leakage that may occur is to atmosphere and not into the reactor coolant circuit. The principle has been derived from an earlier Babcock and Wilcox practice which was employed where contact between high and low temperature water was undesirable. The thermal sleeves are welded to the shells, and the welds tested by filling the sleeves with halogen gas under pressure and applying an ionising gun to the weld exterior. This operation is seen being carried out in Fig. 5.

RESEARCH AND HEAT TRANSFER

A new technology demands new techniques, and problems of atomic energy are therefore a major feature of the work at the Babcock and Wilcox Research Station near the Renfrew factory. The station, which is to be extended, employs a staff of over 270 and is extensively equipped with modern apparatus for chemical and physical testing and analysis, mechanical testing, metallurgical examination and application of electronics to engineering. It will be appreciated that, in the field of nuclear power generation, the problems of heat exchange are relevant both to the steam-raising equipment and the design of reactor fuel elements, and the latter introduces, in addition, a wide range of new problems of a mechanical, chemical and metallurgical nature. The heat-transfer department therefore performs work on both heat-exchange tubes and fuel-element cans. Test assemblies of heat-exchanger tubes having a wide range of extended surfaces and arranged in elements with appropriate water circulation connections are located in a vertical flue in the hot-gas flow from a remote oil-fired combustion chamber. Conditions are controlled to resemble those in a steam raising tower of a nuclear power plant. A more advanced rig using a closed gas circuit at elevated pressure is being designed and will enable tests at considerably higher temperatures and heat ratings to be performed.

FUEL CANS

Similar investigations are carried out for the fuel cans but here experience is much briefer since there is no direct link with conventional engineering plant. These cans contain the uranium fuel in a reactor and serve not only to exclude chemical reactions between the uranium and the surrounding atmosphere, but more important to prevent the escape of the radioactive fission products evolved during the fission process. Quick-sorting tests are carried out over a wide range of cans with a great variety of extended surfaces, so that less likely designs can be quickly eliminated. Fig. 6 shows a few of the 300 types of finned can already tested—though it is unlikely that they include the can chosen for the C.E.A. projects. For test purposes cans are made from bronze or brass. In the rig built for this purpose representative cans are steam heated in a lagged cylindrical vessel through which air is circulated, simulating gas-flow in a reactor. Measurements indicate both the air-pressure drop along the surface of the can and the effectiveness of transfer. More accurate investigation is carried out by means of the rig illustrated in Fig. 7, which more closely simulates reactor conditions. The fuel-can is located inside a steel pipe forming part of a closed circuit in which carbon dioxide is circulated under pressure, and the fuel rod is simulated by an electrically heated element inside the can. Facilities are provided for a wide range of measurements such as flow, pressures, temperatures, electrical input to the fuel rod and others. The heat rating of a reactor fuel element is so high that conventional methods of electrical heating suitable for introduction into a confined space were inadequate, but a novel technique developed

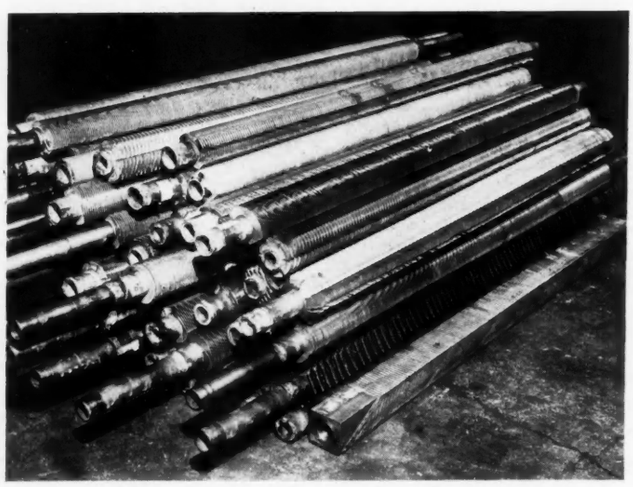

Fig. 6 Some of the 300 types of finned fuel can tested by Babcock and Wilcox. Test cans are made from bronze or brass and their flow and heat-transfer characteristics examined.

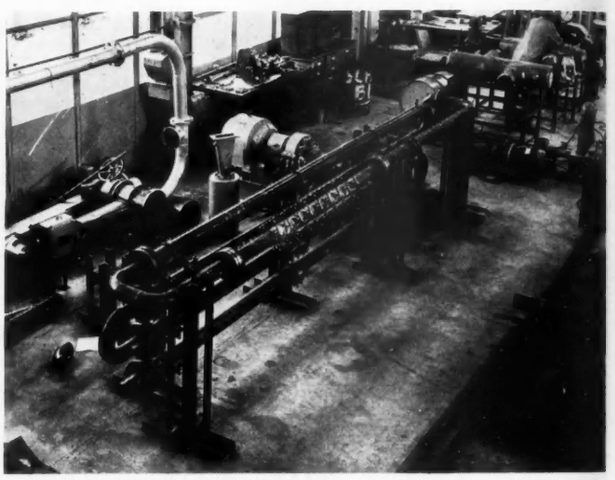

Fig. 7 Test rig for fuel cans, simulating the conditions in the fuel channels of a gas-cooled reactor. A provisional selection of cans is made by a quick-sorting machine operating on a similar basis.

points concerning their manufacture and testing that may be of interest. The 80 ft. towers are fabricated on site from six cylindrical sections and two domed ends; these ends are made by welded fabrication from segment plates formed in a recently installed 2,000 ton hydraulic press. The press will also be used for forming the dished plates necessary in the construction of reactor pressure vessels and can deal with steel plate up to 7 in. thick. Controlled from a central panel, it is unusual in that the power-operating cylinders are located in a 40 ft. pit. A sliding table carrying the lower die simplifies positioning of the plate after pre-heating in an adjacent furnace. There is also an 8,000 ton press for cylindrical shell bending which can form plate up to 8 in. thick. It is worth noting that the number and size of sections in heat exchangers for future stations may depend on the capacity of roads and bridges between the factory and the site.

Heat exchanger elements must be made from tubes that are clean both internally and externally, and as the Calder Hall plant is designed for operation at relatively low pressure, the requirements are most conveniently met by electric

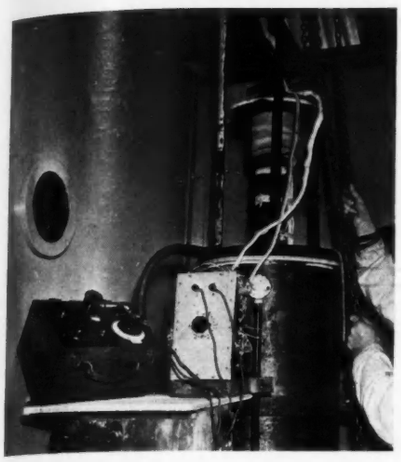

Fig. 8 Temperature cycling tests on reactor fuel element and can. Differential expansion of fuel and can may give rise to ratchetting, or the creeping up of the can on the fuel rod.

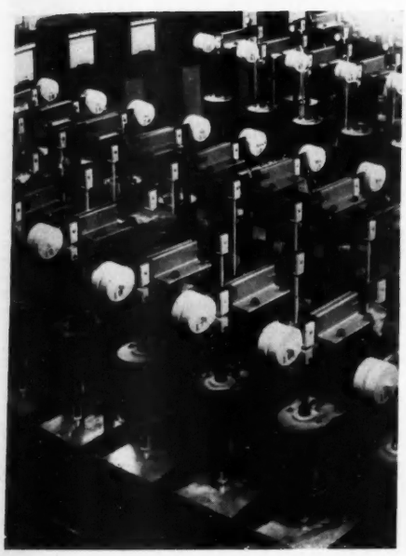

Fig. 9 High-temperature tensile fatigue testing.

at the station has successfully overcome this difficulty. Tests have been carried out with a simulated heat rating of 15 kW per ft.

Fuel elements introduce many other problems and these are tackled in the chemical, metallurgical and mechanical engineering research departments. In the chemical department, for example, compatibility tests are being carried out on materials suitable for the fuel cans. At present the working temperatures are of the order of 400 to 450 deg. C. when using uranium in a carbon dioxide atmosphere and enclosed in graphite. The special requirements for these cans are a material having adequate strength and ductility at high temperature, good heat transfer, a low absorption of neutrons and compatibility with the fuel and coolant. Materials for this purpose under investigation at present include magnesium alloys such as Magnox, and other materials with low neutron absorption such as alloys of zirconium. It is not known whether work is being carried out on beryllium alloys, which are also under consideration for fuel-canning purposes. Equipment is also being designed for a prolonged series of tests to examine the corrosion effects of these and similar materials in a carbon dioxide atmosphere at high temperatures under dynamic conditions, and investigations are envisaged into the chemical problems (compatibility, for example) associated with liquid-metal reactors.

It is of related interest that the United States Babcock and Wilcox company, with which the United Kingdom company are not directly associated but have nevertheless some general contact, have recently opened a privately financed fuel-element fabrication plant at Lynchburgh, Virginia. Work so far has been largely confined to flat plate type elements. It has also been reported that elements canned in Zircalloy (a zirconium alloy) have been successfully made.

THERMAL CYCLING

The effect of temperature cycling on canned fuel elements, involving metals of different expansion characteristics is examined in a test rig in which a sample fuel element comprising a uranium rod enclosed in a Magnox can is subjected to changes of temperature corresponding to insertion into and withdrawal from a reactor. The rig, which is the responsibility of the metallurgical department, is illustrated in Fig. 8. The sample fuel element enclosed in a steel tube containing argon gas is lowered into an electrically heated chamber maintained at about 400 deg. C. and is periodically removed and cooled to room temperature. Numerous thermocouples, placed at intervals along the steel container, enable accurate temperature readings to be taken. The " ratchetting " effect that may result from the unequal expansions of fuel rod and can is observed by means of X-ray photography (see ENGINEERING, October 12, page 472, 1956). Another problem which has to be tackled is the growth of the fuel rod as the result of irradiation and the formation of fission products. This may cause damage to the fuel can and hence release of fission products. Fuel cans must also be strong enough in vertical fuel channels like those in the Calder Hall station to support without distortion those elements above. However, this difficulty may be overcome in later designs. In addition, it is likely that a more satisfactory method of loading and unloading will be developed.

PRESSURE VESSELS AND MATERIALS

Long-period scaling tests have been carried out in the chemical department in connection with materials for high-pressure boilers fired with a wide variety of fuels, and the results are extrapolated to the equivalent of 100,000 hours of service. The apparatus can readily be adapted to investigate the performance of materials used in nuclear power plant construction, under conditions simulating those of actual operation. A new extension to the chemical laboratory will include additional spectrographic equipment to facilitate analysis of new or unusual materials likely to be used in nuclear equipment, where determinations of minute trace elements may be of considerable importance.

The design of large pressure vessels for housing reactors introduces many new problems, due largely to the fact that the working pressure must be withstood by a vessel of much larger diameter than normally required in pressure vessels, and also to the complex construction and sealing provisions necessary in accommodating the complex reactor structure and the arrangements for insertion and withdrawal of fuel elements and control rods. To assist in the design of such vessels, and also of reactor components subject to varying pressure and temperature conditions, the mechanical department is engaged in investigations into the performance of materials used in reactor construction. These involve a wide range of orthodox mechanical tests, and also particular attention to such aspects as brittle-fracture related to special alloy steels, and the creep properties of steel and of light non-ferrous alloys.

FATIGUE AND HOT STRESS

Fatigue tests on such materials are carried out by conventional reverse-bending at various speeds at room and increased temperatures and, in some cases, with corrosive liquids applied to the specimen. In addition slow tensile fatigue testing of large specimens at working temperature is being performed in test rigs constructed in the station workshops. A high-temperature tensile fatigue testing apparatus appears in Fig. 9. For hot-rupture tests, a bank of 84 hot-stress-rupturing machines, some of which can be seen in Fig. 10, is installed. Certain of these are at present engaged on samples of the Magnox alloy used for fuel cans. The number of machines devoted to such tests will be much increased shortly when a new extension to the laboratory is complete. The design of conventional high-temperature steam-raising plant requires data from hot-rupture tests only, as permanence of dimensions is not of primary importance. In certain nuclear applications, however, the amount of creep strain is important. For this reason 24 creep testing machines are also being installed. This extension will grealy facilitate tests on alloys of aluminium, beryllium, zirconium and on other materials developed for nuclear-power applications.

TESTING TO DESTRUCTION

The study of pressure vessel performance including testing to a point of failure forms an important part of the work of the mechanical research department, where there has been installed since 1952 a Werner and Pfleiderer pulsating pressure plant capable of hydraulic fatigue testing full-size pressure vessels at loads up to 4,500 lb. per sq. in. The new extension of some 3,600 sq. ft. area will enable more space to be devoted to these tests and accommodate large scale versions of such pressure vessels as prototype reactor chambers. In order to deal with the higher pressures envisaged for all types of vessels additional pulsating hydraulic test plant is being installed for pressures up to 6,000 lb. per sq. in.

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The October, 1956, issue of " Scientific Film Review " published by the Scientific Film Association, 164 Shaftesbury-avenue, London, W.C.2, contains details of 145 films on atomic energy and related subjects. The journal (vol. 2, No. 4) is available price 3*s.* 6*d.*

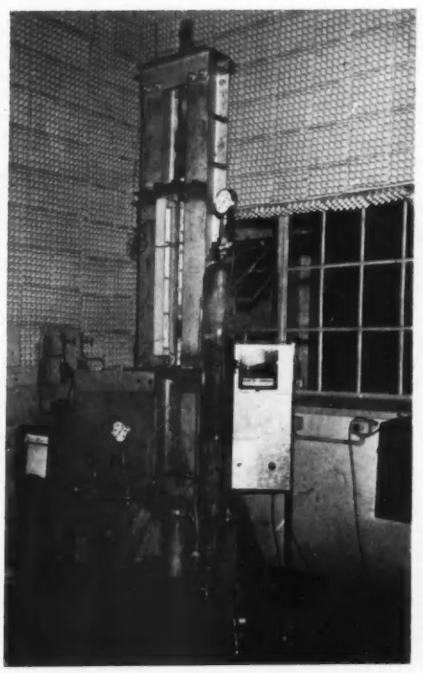
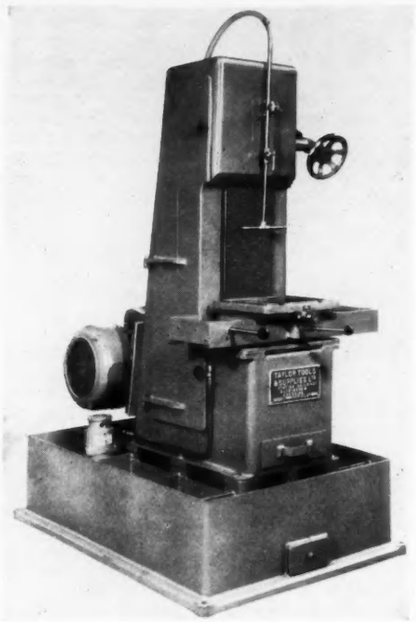


Fig. 10 Part of a battery of 84 hot-stress rupturing machines at the Babcock and Wilcox Research Station. More are to be added.



The Taylor wet belt grinder can have a plain fixed table, a hand-operated table with a micrometer stop, or work fixtures for automatic operation.

FAST MACHINING BY ABRASIVE BELT

Wet abrasive belt grinding offers many advantages over other machining methods for certain purposes. It is particularly fast because the whole of the surface to be ground can be brought into contact with the abrasive surface simultaneously, and as the cutting pressure is low, fragile work can also be operated on at high speed, without risk of distortion. Non-metallic materials such as glass and plastics can be ground by the wet belt as well as metals.

The machine illustrated herewith has been introduced by Taylor Tools and Supplies, Limited, Vortex Works, Broadheath, Altrincham, Cheshire, to use to the best advantage the electro-coated, resin-bonded abrasive belts now available. The belt is carried on two pulleys, both of which are fully supported at both ends by ball and roller bearings, protected by labyrinth seals. It can be run at speeds ranging from 2,500 to 5,500 ft. per minute, according to requirements. The maximum width of belt is 9 in. Handwheels are provided for tensioning and tracking the belt, and there is screw adjustment to the platen carrier for squaring with the work table.

The design of the machine allows for free-hand grinding on a fixed, plain table; for the use of a hand-operated micrometer-stop table on anti-friction ways, as shown in the illustration, or for work-fixture and automatic operation. The hand-operated table has ½ in. T-slots.

A 75 gallon coolant tank is built into the base of the machine and divided into multiple compartments for coolant clearing by settlement. Coolant is circulated by a motor-driven centrifugal pump and directed to three points. A distribution pipe above the work serves for cooling, a second pipe at the back of the belt lubricates it in its passage over the platen, and a third pipe below the work table cleans the belt.

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In our article describing the production of Ferranti computers (October 19, page 489), the package units from which "Pegasus" is built up were referred to as "plug boards." A more accurate description would be "plug-in units."

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

HOVE
"Motor Control Gear," by R. F. Mathieson. Brighton, Hove and District Branch. New Imperial Hotel, First-avenue, Hove. Wed., Nov. 28, 7.30 p.m.

British Institute of Management

GLASGOW
"Can Office Management Help Sales?" by A. M. Parkinson and H. B. Pearson. St. Enoch Hotel, Glasgow. Fri., Dec. 14, 7.15 p.m.

British Interplanetary Society

LONDON
"Use of Probe Rockets," by C. A. Cross. Caxton Hall, off Victoria-street, S.W.1. Sat., Dec. 1, 6 p.m.

Building Centre

LONDON
Film on "The Uses of Mobile Cranes in Building," exhibited by George Cohen, Sons and Co., Ltd. Wed., Nov. 28, 12.45 p.m.

Chemical Society

BIRMINGHAM
"Hydrocarbon Compounds of the Transition Metals," by Professor G. Wilkinson. Birmingham Branch. Chemistry Department, The University, Birmingham. Fri., Nov. 30, 4.30 p.m.
CAMBRIDGE
"Sorption of Vapours in Crystals," by Professor R. M. Barrer. Cambridge Branch. University Chemical Laboratory, Lensfield-road, Cambridge. Fri., Nov. 30, 8.30 p.m.

Illuminating Engineering Society

LONDON
"Blackpool Illuminations," by H. Carpenter. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Nov. 27, 6 p.m.
BRISTOL
"Lighting for Inspection," by H. E. Bellchambers. Bath and Bristol Centre. Royal Hotel, Bristol. Mon., Nov. 26, 7 p.m.
LEEDS
"My Most Interesting Lighting Job": four short papers by S. Addison, J. W. Bessant, K. Graham and H. Laycock. Leeds Centre. Lighting Service Bureau, 24 Aire-street, Leeds, 1. Mon., Nov. 26, 6.15 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Canning," by R. F. Rooke and Miss Christine MacNab. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Nov. 30, 7.30 p.m.
CARDIFF
"Inert Gas Welding Processes" (with film), by A. Woollcott. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Nov. 27, 7.15 p.m.
CHESTER
"Electrical Hazards," by D. A. Picken. Merseyside and North Wales Branch. Stafford Hotel, City-road, Chester. Thurs., Nov. 29, 7.15 p.m.
LEEDS
"Electronics in Industry," by F. G. Totty. West and East Yorkshire Branch. The University, Leeds. Mon., Nov. 26, 7.30 p.m.
SHEFFIELD
Discussion on "Automation." Sheffield Branch. Grand Hotel, Sheffield. Thurs., Nov. 29, 7.30 p.m.

Institute of Fuel

LONDON
"Cost in Britain of Air Pollution from Different Types of Source," by Dr. R. S. Scorer. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Nov. 28, 5.30 p.m.*

Institute of Marine Engineers and Institution of Naval Architects

LONDON
Joint Nuclear Marine Propulsion Panel's first meeting. "Some Safety Considerations of Nuclear Power Reactors," by C. D. Boadle. 85 Minories, E.C.3. Tues., Nov. 27, 5.30 p.m.*

Institute of Marine Engineers

BATH
"Passenger Liner with Engines Aft," by R. K. Craig. West of England Section. York House Hotel, George-street, Bath. Mon., Nov. 26, 7.30 p.m.
BELFAST
"Reheating as a Contribution to the Economy of the Marine Steam Turbine, with Special Reference to the Installation of the T.S.S. Empress of Britain," by A. W. Davis. Northern Ireland Panel. College of Technology, Belfast. Tues., Nov. 27, 7.30 p.m.
KINGSTON-ON-THAMES
"Marine Diesel Engines," by A. G. Arnold, presented by D. B. Stables. Junior Lecture. Kingston Technical College, Kingston-on-Thames. Wed., Nov. 28, 2.30 p.m.

Institute of Road Transport Engineers

DURHAM
Open Meeting. North Eastern Centre. Three Tuns Hotel, Durham City. Tues., Nov. 27, 7 p.m.

Institution of British Agricultural Engineers

BIRMINGHAM
"Modern Equipment for Milk Production," by H. S. Hall. West Midlands Centre. Works of Wolseley Engineering, Ltd., Witton, Birmingham. Mon., Nov. 26, 7.30 p.m.

Institution of Civil Engineers

LONDON
"Analysis of Prestressed-Concrete Structural Members and the Application of Recent Research," by Dr. P. B. Morice. Structural and Building Division. Tues., Nov. 27, 5.30 p.m.* "Conservation of Natural Resources."—V. "Metallic Corrosion and Conservation," by W. H. J. Vernon. Thurs., Nov. 29, 5.30 p.m.*
INVERNESS
"Highway Bridge Loading," by W. Henderson. Glasgow and West of Scotland Association. Burnett's Tearooms, Academy-street, Inverness. Thurs., Nov. 29, 7.30 p.m.
SHEFFIELD
"Analysis of Prestressed-Concrete Structural Members and the Application of Recent Research," by Dr. P. B. Morice. Yorkshire Association. Grand Hotel, Sheffield. Fri., Nov. 30, 6.15 p.m.

Institution of Electrical Engineers

LONDON
"The Automatic Solution of Power-System Swing-Curve Equations," by C. Adamson, L. Barnes and B. D. Nellist; "Electronic Analogue-Computer Study of Synchronous-Machine Transient Stability," by A. S. Aldred and P. A. Doyle; and "Dynamic Operation of an Alternating-Current Network Analyser," by S. Kaneff, presented by I. MacDonald. Supply Section. Wed., Nov. 28, 5.30 p.m.*
"Differences of Opinion About Dimensions," by Professor R. O. Kapp. Thurs., Nov. 29, 5.30 p.m.*
BIRMINGHAM
"High-Voltage Technology and Insulation Engineering," opened by Dr. J. B. Higham. South Midland Centre. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Nov. 29, 6.30 p.m.*
BRIGHTON
"Highland Water Power: The Developments of the North of Scotland Hydro-Electric Board," by the late T. Lawrie. Southern Centre. Brighton Technical College, Brighton. Wed., Nov. 28, 6.30 p.m.
BRISTOL
Faraday Lecture on "Nuclear Energy in the Service of Man," by Dr. T. E. Allibone. Western Centre. Colston Hall, Bristol. Thurs., Nov. 29, 6.30 p.m.
FARNBOROUGH
"An Approximate Method for Finding the 'Best Linear Servo Mechanism'," by Dr. H. H. Rosenbrock. Southern Centre. R.A.E. Technical College, Farnborough. Mon., Nov. 26, 7.30 p.m.
MALVERN
"Control and Instrumentation of a Nuclear Reactor," by A. B. Gillespie. South Midland Centre. Winter Gardens, Malvern. Mon., Nov. 26, 6. p.m.*
NEWCASTLE-UPON-TYNE
"Underground Lighting in Coal Mines," by Dr. C. D. J. Statham. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Nov. 26, 6.15 p.m.
WEYMOUTH
"Human Engineering," by B. Shackel. Southern Centre South Dorset Technical College, Weymouth. Fri., Nov. 30 6.30 p.m.

Institution of Engineers-in-Charge

LONDON
Presidential Address by Lord Sempill. E.L.M.A. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Wed., Nov. 28, 6.30 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Oil Firing of Central Heating Boilers," by B. A. Williams. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Nov. 27, 6.30 p.m.
EDINBURGH
"Assessment of Subjective Reactions in Heating and Ventilating Research," by F. A. Chrenko. Scottish Branch. 25 Charlotte-square, Edinburgh. Tues., Nov. 27, 7 p.m.

Institution of Mechanical Engineers

LONDON
Debate on the motion "That There is no Future for Laminated

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury, square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 8 Hill-street, London, W.1. (GROsvenor 6000.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgrave 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

Plastics in Automobile Body Construction." Automobile Division. Wed., Nov. 28, 6.45 p.m.*
"The American System of Education and Training of Mechanical Engineers," by Dr. H. S. Arms; and "The Education of Engineers in European Countries," by Professor S. J. Davies. Meeting in conjunction with the Education Group. Fri., Nov. 30, 6 p.m.*
BRISTOL
"Heating and Ventilating Systems for Passenger Service Vehicles," by Wing-Commander T. R. Cave-Brown-Cave. Western A.D. Centre. Royal Hotel, Bristol. Fri., Nov. 30, 6.45 p.m.
CHELMSFORD
"Application of Atomic Energy to Power Production," by Dr. S. C. Curran. Eastern Branch. Hoffman Hall, Chelmsford. Thurs., Nov. 29, 7.30 p.m.
LINCOLN
"Crankcase Explosions: Development of New Protective Devices," by Dr. W. P. Mansfield. East Midland Branch. Technical College, Lincoln. Thurs., Nov. 29, 7.15 p.m.

Institution of Production Engineers

AYLESBURY
"Making Jigs, Tools and Moulds in Epoxide Plastics," by P. G. Pentz. Oxford Section. Ye Olde Bull's Head, Aylesbury, Oxon. Tues., Nov. 27, 7.30 p.m.
BEDFORD
Discussion on "Transfer Machines." Luton Section. Works of W. H. Allen, Sons & Co. Ltd., Bedford. Tues., Nov. 27, 7.30 p.m.
BRISTOL
"Some Engineering Problems Associated with the Experimental Atomic Reactor," by W. F. Wood. Western Section. University Engineering Laboratories, University-walk, Bristol, 8. Wed., Nov. 28, 7.15 p.m.
MANCHESTER
"Modern Forging Practice," by H. Hayes. Manchester Section. College of Technology, Manchester. Mon., Nov. 26, 7.15 p.m.
STOKE-ON-TRENT
"Cutting Tools: Application and Research," by M. O. Short. Grand Hotel Stoke-on-Trent. Mon., Nov. 26, 7.30 p.m.
WORCESTER
"Process Development of Shell Moulding," by J. Fallows. Worcester Section. Cadena Café, Worcester. Wed., Nov. 28. 7.30 p.m.

Institution of Structural Engineers

SHEFFIELD
"Analysis of Prestressed-Concrete Structural Members and the Application of Research," by Dr. P. B. Morice. Yorkshire Branch. Grand Hotel, Sheffield. Fri., Nov 30, 6.15 p.m.

Institution of Works Managers

LANCASTER
"Practical Interpretation of a Balance Sheet: Profit and Loss," by J. Farquharson. Storey Institute, Lancaster. Tues., Nov. 27, 7.30 p.m.

Junior Institution of Engineers

LONDON
Annual General Meeting. Fri., Nov. 30, 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
Acheson Centenary Lecture: "Carborundum and Electric Furnace Graphite: The Work of Dr. Edward G. Acheson" (with film), by E. A. Smith. Wed., Nov. 28, 6 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Nominal Cleavage Strength of Steel and Its Importance for Welded Structures," by T. Norén. Mining Institute, Newcastle-upon-Tyne. Fri., Nov. 30, 6.15 p.m.

Reinforced Concrete Association

GLASGOW
"A New Method of Concrete Mixing by Continuous Automatic Process," by R. T. Richards. Scottish Branch. St. Enoch Hotel, Glasgow. Mon., Nov. 26, 6.30 p.m.*

Royal Institution

LONDON
"Speed on the Road and Related Effects," by Dr. W. H. Glanville. Fri., Nov. 30, 9 p.m.

Royal Meteorological Society

EDINBURGH
"Infra-Red Solar and Atmospheric Spectrographic Measurements from Balloons up to an Altitude of 100,000 ft.," by Dr. D. M. Gates. Scottish Centre. Department of Natural Philosophy, The University, Drummond-street, Edinburgh. Fri., Nov. 30, 5 p.m.*

Royal Society of Arts

LONDON
"Engineering Electronics," by Dr. L. E. C. Hughes. First of three Cantor Lectures. Mon., Nov. 26, 6 p.m.
"Air Conditioning of Buildings," by J. S. Hales. Alfred Bossom Lecture. Wed., Nov. 28, 2.30 p.m.

Royal Statistical Society

SHEFFIELD
"Linear Programming in Industry," by M. A. Aczel. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., Nov. 29, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Feeding Compounds," by D. W. Leonard. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Nov. 27, 7 p.m.

Society of Chemical Industry

BRISTOL
"Stress Corrosion," by K. R. Wilson; and "Corrosion Fatigue," by T. D. Weaver. Joint Meeting of Bristol Section and Corrosion Group. Chemical Department, The University, Woodland-road, Bristol. Thurs., Dec. 6, 6.30 p.m.

Society of Instrument Technology

LONDON
"Television Technique Applied to Observation and Control," by Professor J. D. McGee. Manson House, Portland-place, W.1. Tues., Nov. 27, 7 p.m.*
GLASGOW
"Air-Operated Controllers," by A. B. Parry. Scottish Section. Building Centre, 425 Sauchiehall-street, Glasgow. Fri., Nov. 30, 7.15 p.m.

ATOMIC REVIEW

Alternative Approaches

Future of gas-cooled reactor discussed at Calder Works Symposium—Flux flattening—Boiling reactors with minimum instability—Reactors for Japan from Britain?—Continuous treatment of cable insulation by accelerator beam—DIDO inaugurated—Radioactive isotope course—Atomic Energy Authority Bulletin.

Calder Symposium and Future Reactors

Yesterday and to-day the British Nuclear Energy Conference is holding a "Symposium on Calder Works Nuclear Power Plant." One of the most important conclusions to emerge from the Symposium is that plants basically similar to Calder Works are likely to be built 25 years from now, and that improvements to the PIPPA type of reactor (as used at Calder Hall) will enable us to maintain our lead in reactor technology for at least a decade (Sir Christopher Hinton). It has been suggested elsewhere that liquid-metal cooled reactors, such as the sodium-graphite reactor, on which a feasibility study is being conducted, may not prove any more economic than advanced gas-cooled reactors (Sir John Cockcroft speaking before a meeting of the World Bank). Mr. R. V. Moore referred during the Symposium to very-high-temperature (VHT) reactors using ceramic fuels (compounds of uranium, plutonium or thorium with oxygen or carbon). The fuel would be virtually diluted in a moderator and the gas outlet temperature might approach 800 deg. C. He also discussed gas-turbine cycles suitable for use with reactors. A further point in favour of the gas-cooled reactor is the value of concentrating on improving a system which is already well established. We hope to say something more about the Symposium in a later article. Papers and discussions will be printed in the April and July, 1957, issues of the *Journal* of the B.N.E.C.

Reactor Output

Methods of increasing gas-cooled reactor output were widely discussed at the Symposium. One familiar means of improvement to which we have not previously referred is "flux flattening." The factors (contingent on pressure-vessel strength or thickness) which may contribute to raising reactor output, including flux flattening are discussed below. The output of a reactor can be improved by increasing its size and raising the coolant-gas operating pressure. Higher working temperatures will of course also effect an improvement. Increased pressures bring improved heat transfer, though to a diminishing extent, and it is thought that a reasonable coolant pressure to aim at in the C.E.A. stations is 150 lb. per sq. in., as against the 100 lb. per sq. in. pressure chosen for Calder Hall. Increasing reactor size naturally gives a greater output, but also enables a greater volume of the reactor to operate at the maximum permissible temperature. This is achieved by flux flattening. The Calder Hall reactors only just exceed the critical size necessary for a chain reaction to be maintained; thus reactivity at the centre will be considerably higher than at the periphery. With a larger reactor having greater excess reactivity, absorbing material can be inserted at the centre so that the neutron flux on which reactivity depends will be flattened, or made uniform across the reactor. The heat output from different fuel channels will also vary less, and a greater number may then be operated at the maximum temperature permitted by canning materials and other considerations.

Forced Circulation Boiling Reactor

It has been suggested that the simple boiling-water reactor cycle, in which steam produced by boiling in the reactor core is carried directly to a turbine, is in effect a condensing gas-turbine cycle. With the use of modest temperatures and pressures higher efficiencies are promised than are likely to be attainable with conventional gas turbine cycles using far higher temperatures. If considerations of carry-over of radioactivity into the steam turbine transpire to be negligible, as is quite likely, no heat exchangers will be required. Further, the reactor will shut down automatically in the event of an excursion (see "Testing a Reactor to Destruction," ENGINEERING, vol. 181, page 36, 1956). However, the formation of steam voids in the reactor core

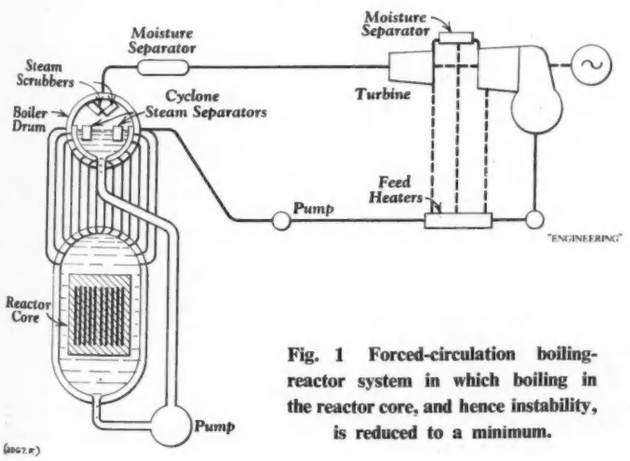

Fig. 1 Forced-circulation boiling-reactor system in which boiling in the reactor core, and hence instability, is reduced to a minimum.

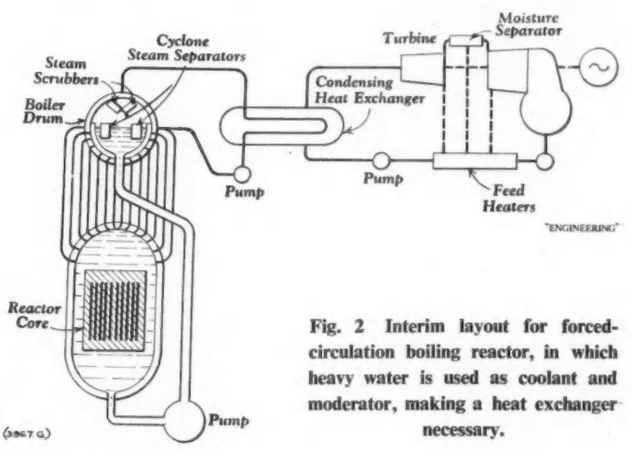

Fig. 2 Interim layout for forced-circulation boiling reactor, in which heavy water is used as coolant and moderator, making a heat exchanger necessary.

disturbs the moderating effect of the water, so causing variation in the neutron flux and hence instability. To overcome this, boiling reactors have been proposed which combine the features of boiling and pressurised-water systems. (In a pressurised-water reactor the water is maintained at a sufficient pressure to permit the achievement of high temperatures without boiling.) The system described here should not be confused with those in which a flash boiler is employed. In this case, by using forced-circulation, the quantity of water pumped through the reactor core may be as much as twenty times the steam output, with the result that the fraction of steam produced in the core may be as little as 5 per cent. Thus voidage effects are minimised.

This arrangement may be achieved in the manner illustrated in Fig. 1. The reactor vessel is linked to a second vessel above it by a number of tubes and water fills the lower vessel and part of the upper. Steam evolved in the reactor rises through the tubes, is released at the free water surface and passes to the turbine, where after expansion it is condensed, heated by steam bled from the turbine and returned to the upper vessel. At the same time, a pipe leading from the bottom of the upper vessel to the base of the reactor vessel allows the bulk of the water in the two vessels to circulate continuously. The upper vessel would contain orthodox steam separating and scrubbing devices and, in addition, there would be other moisture separating means between the reactor system and the turbine, and at appropriate stages in the turbine itself. The system could be operated with either light or heavy water, the former requiring enriched fuel. An interim system employing heavy water and a heat exchanger is shown in Fig. 2 Here, the heat exchanger serves two purposes: it conserves heavy water, since the remainder of the system including the turbine, condensers, feed-heaters and pipelines contains light water, and it provides a barrier for carry-over of radioactivity until more is known about this problem.

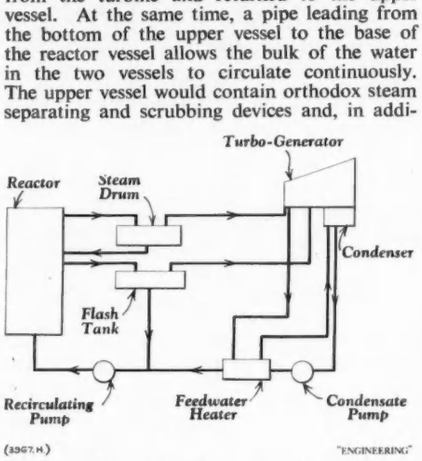

Fig. 3 Dual-cycle boiling system in which both steam and water are taken from the reactor, the water being converted to steam in a flash boiler.

The boiling reactor is believed by Mr. W. R. Wootton of the Atomic Energy Department of Babcock and Wilcox, Limited, to offer scope for the future development of nuclear power; it may be equally applicable to both large and small plant. Mr. Wootton played a considerable part in the design study for the Calder Hall nuclear power station and was particularly concerned with the development of the dual-pressure steam cycle used in that plant. He suggests that the reactor vessel for a plant of considerable magnitude might be 35 ft. high, 12 ft. in diameter and 7 or 8 in. thick; the pressure might be in the region of 2,000 lb. per sq. in. This is roughly the same size as the reactor pressure vessel being made by Babcock and Wilcox for the Canadian NPD plant, though the thickness and pressure are somewhat higher. Mr. Wootton considers that with these conditions the efficiency of nuclear power plant might approach 45 per cent. after allowance has been made for pumping power and other auxiliary requirements. The efficiency of the present projected gas-cooled, graphite-moderated steam stations lies between 25 and 30 per cent.

Canadian Pressure Vessel

We wish to emphasise that the pressure-vessel illustrated in Fig. 3, page 636, last week, is not the vessel being built by Babcock and Wilcox, Limited, for the Canadian NPD project. It was our intention to show generally the kind of vessel that may be used, though, of course, there may well be important differences.

Dual-Cycle Boiling Reactor

The scheme favoured by Mr. Wootton should be distinguished from the " dual-cycle " principle involving a flash boiler developed by the United States General Electric Company and described in a paper at the 1956 World Power Conference. A schematic layout of one type of dual cycle is shown in Fig. 3. Heat is taken from the reactor in two forms, so that the system is in fact divided: first, as steam which is delivered to the inlet stage of the turbine, and second, as water at the same temperature as the steam; this passes to a flash boiler and thence as steam to an intermediate stage in the turbine. The purpose of the second cycle is to provide a source of relatively cool return in addition to heat energy. It is stated that the design results in a readily controllable unit, together with high power density, and still retains the major safety advantages of the simple boiling reactor. An 180 MW power station based on this principle but possibly with minor alterations is being built by the General Electric Company in conjunction with the American Nuclear Power Group for the Commonwealth Edison Company on a site 50 miles south-west of Chicago.

Japanese Delegation

Members of a Japanese atomic power delegation recently visited the Borehamwood establishment of Elliott Brothers (London) Limited, to discuss applications of analogue and digital computers to nuclear reactor and nuclear power station studies. Particular attention was given to the company's nuclear power station computer ND111. The rumours and reports that Japan was to import from the United Kingdom a power station of the Calder Hall type have to some extent lapsed. More recently their initial requirment has been said to be for a station of about 10 to 20 MW capacity. A plant like that at Calder Hall would probably be impracticable under about 40 MW. However, the possibility of exporting a station to Japan has revived with the visit of the Japanese delegation.

Irradiation

In order to investigate the special properties of irradiated dielectric materials, the research organisation of British Insulated Callender's Cables, Limited, have for several months been operating a 2 million volt Van de Graaff accelerator at their Wood Lane laboratories. This equipment was specially chosen for its flexibility in that it can act variously as a source of electrons, positive ions, gamma rays and neutrons. In particular, however, the high-energy radiation thus produced is being used to modify the structure and properties of conventional polythenes. A programme of study of the physical and electrical properties of such materials after irradiation, has been started, with special emphasis on their uses as cable insulants. The irradiation laboratory comprises a central generator block of two storeys, with the target room on the ground floor immediately under the generator room, flanked on each side by cable handling and control laboratories. The concrete walls of the target room are 3 ft. thick to prevent the radiation in the laboratories from rising above the tolerance level, while those of the generator room in which the radiation intensity is lower, are 2 ft. thick. Cable under irradiation traverses the target room through two slits in the concrete walls, and is handled by conventional take-up and haul-off cable machinery. The leakage of dangerous amounts of X-radiation and of electrons into the laboratories is prevented by covering the slits on the outside with 6 in. of lead bricks and on the inside with rubber snuggers and aluminium doors. The electron beam from the accelerator tube in the generator is scanned electromagnetically so that it emerges from the aluminium window of the scanning bucket as a beam having its longer axis parallel to that of the cable. With these arrangements it has been found possible to process continuously polythene insulated cables. First investigations into the properties of such cables, after irradiation, have indicated that amongst other advantages, a substantially raised softening temperature results. Fig. 4 shows a cable passing through the electron beam. The plant is believed to be the first in Great Britain to process plastic insulated cables in this way, and will greatly assist in the assessment of irradiated materials for general use in the cable industry. B.I.C.C. contributed to the Calder Hall nuclear power station.

Notes and Notices

DIDO, the materials testing reactor at Harwell, was inaugurated last Wednesday by the President of the Royal Society, Sir Cyril Hinshelwood.

Full-time courses on " Radioisotopes and their Uses " are being held by the Department of Chemistry, Sir John Cass College, Jewry-street, Aldgate, London, E.C.3, beginning on Monday, January 14, 1957. Subjects will include: detection and screening of radiation, electronics, instruments, counting techniques, spectrometry, radiography, and health physics. The fee for the course is £30, and inquiries should be sent to the secretary of the College.

The first issue of " Atom," a monthly information bulletin of the United Kingdom Atomic Energy Authority, has recently been published. It contains a variety of news including an account of the Calder Hall opening, the text of talks by Sir Edwin Plowden and Sir John Cockcroft, and summaries of U.K.A.E.A. patents. It also reports that a second international technical conference on the peaceful uses of atomic energy may be held at Geneva for two weeks near or about September 1, 1958. This conference has been recommended by the Advisory Committee on the Peaceful Uses of Atomic Energy.

Fig. 4 Continuous processing of polythene insulation is carried out at the B.I.C.C. irradiation laboratory by passing the cable through an electron beam from a 2 million volt Van de Graaff accelerator.

In Parliament

STEEL IN SHORT SUPPLY

Difficulties and delays in the shipbuilding industry arising from shortages of steel were referred to in questions at one of the sittings of the House of Commons last week. Mr. George Darling (Labour/Co-operative) asked the President of the Board of Trade what action he was taking to ensure that there would be no further falls in the supply of steel to the shipbuilding and other essential export industries, in view of the reductions in overall steel production likely to be caused by reduced oil shipments. Mr. Darling suggested that, if the steel supply situation worsened, the President had a duty to see that the most important users of steel obtained adequate supplies, and that, in that case, some form of control would be required. Mr. F. T. Willey (Labour) asked that there should be discussions with the shipbuilding industry, because, he said, it was not merely a question of supplies being forthcoming but also of the sequence of deliveries.

Mr. Peter Thorneycroft replied that deliveries of steel to the shipbuilding industry during the first nine months of the current year were about 15 per cent. higher than during the corresponding period in 1955. At the same time, he was aware that the shipbuilding industry, as well as other industries, could very conveniently use more steel. He was consulting the Iron and Steel Board about the possible effect of reduced oil supplies on steel deliveries. Discussions with the shipbuilding industry were in progress and the matters referred to by Mr. Willey were being kept in mind. The Iron and Steel Board would see that as much steel as possible was made available.

GRADUATES AS R.A.F. FITTERS

Steps to elicit more information regarding the use being made of engineering and science graduates serving in the armed forces were taken by Mr. Ian Mikardo (Labour). He asked the Secretary of State for Air if he would take steps to identify such graduates, and the holders of equivalent qualifications, who were enrolled in the Royal Air Force and who were serving as fitters, or in similar capacities, where their specialised knowledge was not used.

Mr. Mikardo stated that he had already been informed in a parliamentary answer that the Ministry did not know how many officers even there were with these qualifications engaged in occupations which did not require the use of the qualifications concerned. He further pointed out that he had been told that there were 300 airmen of engineering and science-degree standard who were not being used in accordance with their qualifications.

In his replies, Mr. Nigel Birch said that 50 out of the 300 airmen to which reference had been made were engaged on instructing duties and that most of the rest were acting as fitters. The majority of these graduates were men who had failed to obtain commissions and the Ministry was making the best use of them that it could. The qualifications of all men entering the R.A.F. were taken fully into account when allocating them to trades and were permanently recorded on their individual documents.

NOISE FROM AMERICAN JETS

From time to time, questions are asked about the amount of noise caused by aircraft and the disturbing effects which this has upon industry and individuals. An instance of this occurred last week, when Mr. Arthur Skeffington (Labour) urged the Minister of Transport and Civil Aviation to take steps under section 41 of the Civil Aviation Act, 1949, to regulate the noise caused at aerodromes by the new jet aircraft which the British Overseas Airways Corporation were purchasing from the United States. Mr. Skeffington asked whether the possibility of fitting silencers to this new type of aircraft operating from London Airport was being considered. He understood that quite considerable progress had been made in connection with the fitting of silencers to aircraft generally.

In reply, Mr. Harold Watkinson said that, in the conditions attached to the leases which he had granted to them of sites in the maintenance area at London Airport, the Corporation had accepted an obligation to take all reasonable measures to abate noise. He was confident that the Corporation would carry out this obligation and that any need to use statutory powers for that purpose were not likely to arise.

So far as the fitting of silencers was concerned, he agreed with the observations that had been made. A great deal of work was in progress in that connection. The Conway engine, which was the type to be fitted to the new American aircraft, was rather quieter than some jets. Work was proceeding with the use of mufflers on engines running when on the ground. The use of specially-designed jet nozzles was also being investigated. Much was being done but it was too early yet to estimate what results would attend the efforts being made.

FLAGS OF CONVENIENCE

Problems arising from the chartering of ships flying flags of convenience were raised by Mr. S. S. Awbery (Labour), who desired to know what quantity of oil was imported into Great Britain in 1955 in ships sailing under such flags as those of Panama, Liberia and Costa Rica. He suggested that the giving of such freights to lines flying flags of that kind was encouraging these owners to avoid their obligations under the charter of the International Labour Organisation.

According to estimates by the Ministry of Transport and Civil Aviation, Mr. Watkinson said, the quantity of petroleum oils imported into Britain last year in ships flying the flags of Panama, Liberia, Costa Rica and Honduras amounted to about 7 million tons. As to the general principles involved in making use of such vessels, there were two considerations to be noted. One was that the tonnage referred to represented only a small proportion of this country's imports. The second, and much more important, was that it was not in Britain's widest commercial interest, as a large shipowning nation, to interfere with the rights of shipowners to charter vessels where they liked.

TECHNICAL JOURNALS FOR POLAND

Mr. Douglas Dodds-Parker, the Joint Under-Secretary of State for Foreign Affairs, informed the House that the Government were anxious to see that British technical books and periodicals were made available as widely as possible in Poland. A stock of technical books was available for loan from the library of the British Council Centre in Warsaw. Moreover, the current trade agreement between the United Kingdom and Poland included a quota of £60,000 for exports of British books and journals to that country.

In reply to Mr. John Hynd (Labour), who pointed out that the payment for these works was one of the main difficulties in this matter and that the rate of exchange between the two countries was also a problem, Mr. Dodds-Parker said that he would certainly bear these considerations in mind. At the same time, the information reaching the Foreign Office was to the effect that the Polish authorities were refusing to issue licences. Rather less than £5,000 worth of licences had, in fact, been issued, and it was not believed that the difficulty was entirely one of currency.

Nuclear Power Up to Date

Mr. William Warbey (Labour) pressed for a further statement on the Government's proposals for an expansion and acceleration of their nuclear power programme. He suggested to the Minister of Fuel and Power, that the White Paper *A Programme of Nuclear Power*, produced 21 months ago, was now completely out of date, both in regard to the tremendous scientific and technical progress made since then, and on account of this country's growing need to increase uncertain oil supplies. Mr. Aubrey Jones answered that the tenders for the first stations had only recently been received by the Central Electricity Authority. He had asked that the examination of these documents should be carried out with all possible expedition but, until it had been completed, no exact re-assessment of the programme could be made. He agreed that the White Paper of February last year was out of date on both the grounds mentioned by Mr. Warbey. It was hoped that before long, and possibly by the end of the year, it would be possible to announce more precisely a revision of the Government's nuclear energy programme.

European Customs Union

The House was told by Mr. Thorneycroft that no formal communications had been received by the Government regarding the agreement that had been reached by the six nations on the main principles involved in the formation of a European Customs Union, although the report on which the six nations were basing their negotiations had been published. He informed Mr. A. F. Holt (Liberal) that Britain and other European nations, including the six nations directly concerned, were all engaged, even now, in considering the technical aspects of the problems involved.

Standard for Flammable Materials

Mr. Thorneycroft informed Mrs. Patricia McLaughlin (Ulster Unionist) that the British Standards Institution hoped to publish before long a standard describing and correlating agreed methods of testing flammability in textiles. The committee of the B.S.I. dealing with this complex problem was also considering what information should be given to the public regarding flammability in fabrics and garments.

Mineral Development in the Commonwealth

A plea for the early publication of the report of the Commonwealth Economic Committee on the development of raw materials and mineral resources was made by Mr. A. Fenner Brockway (Labour). In reply, Lord John Hope, the Under-Secretary of State for Commonwealth Relations, said that the committee's inquiries had reached an advanced stage. The work of co-ordinating and bringing up-to-date the material collected, and of drafting the report, was already in hand. It was not possible, however, to state precisely when the report would be available.

Technical State Scholarships

In answer to a plea by Captain G. R. Chetwynd (Labour) for an increase in the number of technical state scholarships, Sir David Eccles, the Minister of Education, said that he was considering the number of these scholarships. Any changes in existing arrangements would be announced in time for the next academic year. Captain Chetwynd also sought to know the number of these scholarships awarded to students attending colleges which set their own internal final examination, as compared with technical colleges taking the recognised externally-set examination papers. Sir David expressed his regret that this information was not available, but he invited Captain Chetwynd to consult him on the particular problem he had in mind.

Southend Railway Electrification

In reply to Mr. John Parker (Labour), who asked about the progress being made with the electrification of the railways to Southend, Mr. Watkinson said that the British Transport Commission had informed him that the electrification of the railway from Shenfield to Southend was now nearly complete. It was expected that through electric trains from Liverpool Street Station to Southend would start running on December 31 next.

As to the electrification of the line from Fenchurch Street Station to Tilbury and Southend, which was included in the railway modernisation scheme, detailed planning was proceeding. Contracts had been let for certain preliminary engineering works, and these had been begun at several sites.

THE HUMAN ELEMENT

Shipping and petrol restrictions cause dismissals—Improvements in industrial relations must continue—Shared information brings satisfaction—National effort for technicians wanted—Technical knowledge and managerial skill—Reading (and writing) for quick comprehension.

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Redundancy Accepted

Events in the Middle East are already having their impact on car production. Lack of shipping has forced the Rootes Group, Vauxhall and Ford to cut back production. The prospect of petrol rationing at home—now hardly likely to be avoided—is further darkening the prospects of motor car manufacturers. Rootes stated last week that car schedules would be reduced, and some 250 workers dismissed. In addition, certain departments in the Coventry factories, employing about 6,000 men, will go on a four-day week. The Standard Motor Company's Vanguard model is also affected, and the combined effect of these reductions on the Pressed Steel Company's factory—who make bodies for both Rootes and Standard—is likely to result in 1,000 of the 10,000 workers employed at the Cowley factory being dismissed. A statement issued last week by Mr. Jack Thomas, Oxford branch secretary of the Transport and General Workers' Union, and endorsed by Mr. W. E. Lambourne, joint deputy managing director of Pressed Steel, expressed regret that dismissals should be inevitable but said that "it is obviously impossible to keep men if we have no work for them."

Vauxhall are stopping production for three days a month until Christmas, partly because of their inability to get shipping space and partly because exports to several markets in the Middle East have been stopped or shipments postponed. The difficulties involved—at a time when the industry relies on exports to take up the seasonal slack in home sales—are recognised by the unions as well as by the management and it is unlikely that there will be any repetition of the labour unrest occasioned by the first declarations of redundancy last summer.

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Communist Ferment

There is no doubt that the influence of Communism in industry has been given a severe blow by the impact of events in Hungary. The air is thick with resignations and rumoured resignations of influential Communists from the party, many of them important trade union figures. Since the party has concentrated for several years on the infiltration of its influence into the factory, it is natural that it is there that the impact has been most severe. Without doubt, an unscrupulous and disruptive influence in industry has been reduced, at least temporarily, to chaos and comparative impotence.

Three things should be said, however. First, this is only a rout which was already a retreat—as seen in the recent surprise ballot result in the A.E.U. election (still to be completed) for the general secretaryship. Second, defeat of this kind could drive the movement underground and it could be the more dangerous for being the more dishonest. Third, the setback could be no more than temporary if watchfulness were relaxed.

The price of liberty is eternal vigilance, and this is never more true than when dealing with Communism in industry, which for long will provide a breeding ground for mistrust, ignorance and malicious rumour unless active steps to go on improving industrial relations are maintained. It will be time enough to claim success when prominent trade union Communists show that they have finished with dialectical materialism and not just the Russian version of it.

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Keeping Workers Informed

A review of the salient points made in a report shortly to be published by the British Institute of Management, *Presenting Financial Information to Employees*, was given to the Institute's National Conference by Mr. H. Weston Howard, chairman of Hayward-Tyler and Company, Limited. The report is the result of an investigation undertaken under the guidance of a steering committee of representatives of professional accountancy and management bodies, and is based on the detailed examination of the methods used by seven companies. Mr. Weston Howard's company was the second to be investigated and he gives a short case-history of their experience of making the information available.

Less than 20 per cent. of companies in this country give financial information to their employees, and most of these confine themselves to the facts contained in the annual report and accounts. Individual salaries, directors' fees, volume of sales, cost and profit figures relating to departments, products or factories are rarely given. Even senior executives are ill-informed and do not appear "to have an outstandingly better grasp of the company affairs than the average employee." Mr. Weston Howard's own views are that the giving of financial information can only be part of a wider policy, and should be the last step, not the first, in building up the morale and confidence of employees in their management. There are dangers in sharing information, but these are outweighed by the advantages: "Companies carrying out such a policy find out that it pays not only in profits but, quite as important, in satisfied and contented workers."

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Training Technicians

It has been estimated that the number of persons qualifying in science and engineering must be doubled from the 10,000 a year in 1954-55 to 20,000 a year in 1970. The Committee on Scientific Manpower reckons that between this year and 1959 the total requirement of qualified scientists and engineers in all categories will increase by 85,000. This is bound to put an enormous strain on available staff and equipment.

It is, however, rather less than half the problem. In support of this growing army of qualified men with the highest technical training there must be an even larger one of technicians stretching right down to the skilled operative and even to the man with no more than a trained aptitude. This calls for a national effort in training by means of school curricula, extension courses, up-grading schemes, T.W.I. arrangements, etc.

In this connection, the personnel training arrangements of British Oxygen Engineering Limited, which were publicised last week by the Parliamentary Secretary to the Minister of Labour when he was present at the opening of that company's new apprentice training school, are of interest. In the last five years the company has developed five types of training scheme. These cover apprenticeship courses in skilled trades, similar schemes on the production side, "sandwich" courses for engineering degrees in collaboration with local technical schools, graduate apprenticeship schemes for would-be mechanical engineers and apprenticeship courses on the administrative side. The significance of the schemes is the extent of the field they cover.

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Supervisors in the Smaller Firm

The difficult task of training foremen and the owner-managers of small building firms has been tackled by the Eastern Federation of Building Trades Employers. In a paper read to the national conference of the British Institute of Management, the director of the Federation, Mr. R. W. Porter, described the steps that have been taken to improve the managerial skills of the industry. One important point, which applies equally to small engineering concerns, is that the high degree of technical knowledge necessary even in senior executives tended to exclude, or to be regarded as a substitute for, managerial skills.

Week-end courses for general foremen began in March, 1955. Sixty applications were received for 30 places. This year three courses were held with 120 places, and four courses will be held in 1957. The special problem of the building industry is the preponderance of small firms: about half of the Federation's 1,600 members employ less than 10 men, and only 25 employ over 250 men. The courses were therefore subsidised to about half the total cost. The syllabus consisted of five sessions of 2 to 2½ hours each, devoted to such subjects as the principles of management, personnel (including industrial agreements), site organisation and administration. Informal discussions were held between sessions. Follow-up reports showed that the general foremen, in returning to their contracts, sought to put into practice what they had learned on the course.

Week-end courses for senior executives of the large firms were instituted last March at Madingley Hall, Cambridge, to provide instruction in economic and social subjects as well as in the principles of management. This was followed by a course for management students in the industry, and next year two courses will be held for the principals of small firms. The latter were instigated by comments from foremen such as "I wish the Guv'nor were here to hear this." Thus local enterprise has started something for which there is a pressing need throughout British industry, where small firms continue to employ a large proportion of available labour. Mr. Porter's own assessment of progress so far underlines this need: "The most encouraging feature has been the quickening interest at all levels in training."

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Quick Reading Courses

One of the subjects dealt with at the national Conference of the British Institute of Management was the value of quick reading courses. The subject was handled sanely, and a reasonable case made out for the use of quick reading courses for busy executives or for those who are slow or slovenly in their reading habits. It is clearly a subject which leaves ample room for over-enthusiasm on the one hand and sarcasm on the other. It is best looked at as a technique to be used as a tool for quick comprehension—like the slide rule in another context, which has its uses but is no substitute for a knowledge of mathematics.

Like many techniques of this kind, it has been developed in the United States for busy men of limited education who want to get on. To say that is to admit that the main obstacle to the intelligent use of systematised quick reading on this side of the Atlantic is intellectual snobbery. The basic approach to reading in this country, though it is usually sub-conscious, is an appreciation of the classical languages. From that standpoint, reading is an intellectual discipline, an accomplishment and a source of pleasure. This is surely the right basic approach. Reading in its best sense is an accomplishment and channel of communication for intelligent and educated people. After all, cave paintings are often beautiful as well as primitive modes of expression. That is not to say, however, that reading techniques have no place at all.

There is one service that attention to this question might perform. It might attract further interest to the problem of the quality of writing. Quick comprehension of the written word depends as much on simple, concise writing as on rapid reading.

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